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THE INTRINSIC VALUE OF SCIENCE

IN his presidential address to the British Association at Liverpool thirty years ago, Sir Ernest Rutherford, as he then was, surveying the rapid advance of physics since the Association had previously met in Liverpool—a period which had been termed the heroic age of physical science and which Sir Ernest himself was inclined to characterize as the renaissance of physics—made two points which are reflected in the address which his successor in the presidential chair has this year delivered to the Association (see p. 424 of this issue). Sir Ernest Rutherford noted, first, how the remarkable achievements in applied science which he reviewed had been built on the foundations laid by fundamental investigations of workers in pure science, but that these practical applications, in turn, had benefited the fundamental investigator by providing, through the new methods and appliances developed for technical purposes, the means of attacking still more difficult problems. No sharp distinction, said Rutherford, could be drawn between the importance of so-called pure and applied research : both were equally essential to progress, and, without flourishing schools of fundamental research in our universities and scientific institutions, technical research must tend to wither.

Sir Edward Appleton this year once again referred to the achievements of applied science and to the extent to which discoveries in pure science which, in their time, had no obviously practical import, had later proved to be the foundations of major improvements in our material civilization. While, however, he fully recognized the importance of this aspect of science, and that the cost of scientific research was part of the price to be paid for industrial progress, Sir Edward's fascinating exposition of the way in which during the past twenty years or more science has been exploring the mysteries of space was designed to illustrate not the practical value of science but its intrinsic value—that science is illuminating as well as fruitful. He developed a line of thought which can be seen in embryo in the closing paragraphs of his predecessor's address thirty years before.

Sir Ernest Rutherford said that the rapidity of advance in physics had impressed him more and more with the power of the scientific method in extending our knowledge of Nature, and he referred particularly to the importance of a happy blend of experiment and disciplined imagination, especially in a group of individuals of varied mental outlook. In penetrating obscurity we depended above all on the combined efforts of a number of adequately trained ordinary men of scientific imagination. The passage in which Rutherford elaborated the way in which the work of different specialists interacts and co-operation leads to general advance is a remarkable prediction of experience which, for example, operational research has made familiar ; and he referred in concluding to the importance of the intellectual value of scientific work, more especially as providing the intellectual appeal which would attract young men of ability to enter on a scientific career.

Sir Edward Appleton's address, by and large, takes up the theme where Rutherford left it. Leaving on one side for once the utilitarian aspect of science, he expounded brilliantly its intellectual interest, the way in which knowledge and insight supply sufficient reward in themselves and their pursuit provides a satisfying and worthy way of life. He also left on one side any consideration of the cultural or educational value of science; but nevertheless his address provides an outstanding demonstration of those inherent possibilities in science which could be used as vehicles of broad training not inferior in cultural value to the humanities. Quite incidentally, Sir Edward has taken up the theme which the late Sir Richard Gregory was never tired of urging, and has given a notable exposition of the value of science "as one of the great human endeavours to be ranked with arts and religion as the guide and expression of man's fearless quest for truth".

Moreover, it will be noted that, in pointing to the intrinsic value of science itself, Sir Edward did not attempt to claim that science by itself will supply all that is required for a full and complete life. Accordingly, his argument that science, when pursued for its own sake can, and does, provide an essential element in a satisfying life in the world to-day is the more convincing. He puts science in its right place, not simply as a means of doing things, of gaining power over Nature, of winning new knowledge, but as something by which man is enabled to live in a full sense. The passionate desire to explore and understand contributes something to the scientist who experiences it, whether he be amateur or professional, and quite apart from any achievements to which it may lead; and that contribution is just as enriching in its way to human life and experience as the immortal creations of the human spirit in poetry, art or religion, on which science as such has little light to throw.

In directing attention to the value of science as human experience and as a worthy means of expression for the human spirit, Sir Edward illustrated his argument by describing the way in which recent discoveries of great astronomical interest have been advanced at times by the observations of gifted and enthusiastic amateurs, even if the full meaning and implication of the observations had only been revealed by the skill of the professional scientist. In doing this he emphasized a value of science which was well brought out by Dr. C. E. Raven in his study of English naturalists from Neckam to Ray. Dr. Raven holds that Bacon and those Christian thinkers who followed him and founded the Royal Society were not primarily concerned with the benefit of their discoveries to mankind. Their basic conviction was that a more accurate understanding of the Creation would give them a truer knowledge of the Creator's will and thus enable men to live more fully and intelligently in accordance with that will.

Sir Edward Appleton's argument is, if we accept Dr. Raven's interpretation, essentially for the same point of view—that the scientific method of observation and experiment, and the qualities demanded in their pursuit, contribute to an outlook and a view of life that are both worthy and essential if men are to confront the world with understanding and unafraid. So far from reducing life to something cold and mechanical, modern science in its explorations ranges from the heart of the atom to the frontiers of the universe and, like poetry, reveals depths and mysteries beyond and quite different from the ordinary matter-of-fact world to which we are accustomed. Boldly, but with reason, Sir Edward claims that science has given back to the universe that quality of inexhaustible richness, unexpectedness and wonder which at one time it seemed to have taken away.

"Le silence éternel de ces espaces infinis m'effraie", wrote Pascal, and so might a contemporary Elizabethan write of the vastness of the universe being explored to-day, or of the possibilities disclosed by the discovery and application of nuclear fission and other discoveries and developments of our day. But, on reflexion, Pascal added: "Toute notre dignité consiste donc en la pensée. C'est de là qu'il faut nous relever et non de l'espace et de la durée, que nous ne saurions remplir"*. The contribution of science to the understanding of the forces of the universe is an essential element in the formation of a worthy and adequate view of life. Without it man can neither know, nor do, nor steer onward to any proposed haven.

The scientific approach is not only an essential element in the formation of a worth-while view of life; it is also, Sir Edward reminded us, a far more personal and imaginative activity than is sometimes realized. When all allowance is made for the distance that deliberate application to discovery can take us or for the progress which can result from team-work, especially in following up or consolidating a big discovery, the big jumps ahead are usually the adventures and intuitions of a single mind.

That scientific advance still depends so largely on the individual needs emphasizing in a world in which it is common to discount individuality and to foster uniformity, if not conformity. Sir Edward Appleton, however, was concerned to emphasize the extent to which the scientific process requires the fullest and subtlest employment of all our faculties rather than to urge that if the individual is to make his full contribution in science as in art, literature or other creative work he must find the conditions appropriate to creative expression. Many a vital discovery, he remarked, has been nothing else than recognizing the unexpected. Even in experimental work, it was the primacy of an imaginative idea or intuition that often started it all off, and whether like Pasteur we emphasize that chance only visits the prepared mind or, with Sir Edward, stress the importance of asking Nature the right question and in its most direct form, the rigour of the intellectual discipline involved is unmistakable.

A further point was brought out here by Sir Edward. Asking Nature the right question in the right way, or recognizing a theoretical pattern in a tangled skein of experimental data, often has the effect of introducing an element of beauty and elegance into the scientist's work. As he pointed out,

* "Pensées", 206 and 347 (edit. Brunschvicg, Paris).

when we refer to a "beautiful theory" or an "elegant experiment", we do not mean that the experiment is necessarily conclusive, or that the theory is irrefutable or even particularly fertile in its consequences. Rather we mean that it possesses a quality of inevitability—as if it could not have been done or expressed differently without losing something essential. Exactly the most appropriate means had been chosen, and the consequent economy of means or material or of words gives the experiment or theory something of the same character of fitness for the purpose that marks the choice and selection of the artist, sculptor or writer in the production of a great work of art.

More might well be made of this imaginative aspect of science in relation to its creative faculty. "Reason", wrote Shelley, in his "Defence of Poetry", "is the enumeration of qualities already known; imagination is the perception of the value of those qualities, both separately and as a whole. Reason respects the differences and imagination the similitudes of things." Thus to cultivate the use of the imagination in science may both help to counteract the danger inherent in the analytical aspect of science, and simultaneously foster the creative powers on which real scientific advance always depends and the full value of science as a great human endeavour. Shelley's lament that "man having enslaved the elements, remains himself a slave", would then begin to lose much of its force.

Sir Edward did not go beyond claiming, first, that the scientist's approach to Nature demands mental qualities and awareness that make science in itself a worthy pursuit, and one capable of enriching personal life and giving real satisfactions; and secondly, that the skilful exercise of those qualities not only has values that amply justify a scientific vocation but also can on occasion rank with the discrimination exercised by a great artist. He forbore more than a mention of other personal qualities, greatly needed in the world at large to-day, which a scientific vocation tends to develop and which deserve to be recognized and honoured. Sir Edward referred to the tolerance and open-mindedness to new ideas which shone from Rutherford's presidential address to the Association, and which all who knew him recognized as characteristic of the man. He could equally have quoted that passage in Thomas Huxley's letter to Charles Kingsley which has brought inspiration to thousands of scientists, amateur and professional, and to many others who have sought to penetrate the mysteries of life: "Sit down before fact as a little child, be prepared to give up every preconceived notion, follow humbly wherever and to whatever abysses Nature leads, or you shall learn nothing."

These and other qualities are no monopoly of the scientist, though he can justly claim that their development is fostered by a scientific vocation, for the practice of which they are essential. If therefore scientists do well to heed Sir Edward's warning and endeavour to see themselves as others see them, in their weaknesses and limitations as well as in their strength and excellence, there is at least this to be remembered—that in urging that it is to the interest of the community to see that the scientist enjoys the conditions in which he can most effectively pursue his search for truth, we are no more than pleading for the conditions in which all man's most creative work has been done in art and literature, in philosophy, in religion and in science.

To secure or even to re-establish those conditions is a task demanding constant vigilance to-day, and if science is to be pursued for its own sake and enlarge men's horizons and invest the world with deeper significance, that task cannot be neglected. The history of science can furnish examples enough of discoveries and advances delayed because the climate of opinion was unfavourable. To press that point, however, is to return to the pragmatic approach which Sir Edward specifically eschewed. Furthermore, while as a mental discipline science is one of the most complex and far-ranging of our mental experiences, it is only one of those experiences, and one among other values. Sir Edward stressed—and rightly—the imaginative function in science: there is also, and no less important, the analytical function, and these two, if not incompatible, are not easily kept in balance.

This is doubtless one reason why it has been said that the chief limitation of natural science is that it is not human. Without, however, admitting that that is entirely true, it is wise to recognize that the analytical element in science imposes clear limits on the contribution which science by itself can make to the full development of human personality. At the opposite pole from scientific endeavour are ways of thought which do not change and are concerned with what is not new—with things which will not be superseded. Science indeed teaches men not to be afraid of change, but to-day, as Sir Edward Appleton suggested, we need these enduring and sustaining values of the spirit more than ever. In our constant urge to seek fresh truths and new understandings, only too easily do we lose sight of other aspects and values of life, and Sir Edward fitly crowned his brilliant interpretation of the intrinsic value of science with this insistence that it is only one among other and equally great values of human experience.

Scientists may, as he said, be fortunate in that their vocation is, by its very nature, dedication to an end, and they need never lack the opportunity for dedication. But we must admit that the striving of the scientist and his pursuit of virtue and knowledge will not provide the complete human satisfaction unless it is matched by those other great human values to which Sir Edward alluded. In its different setting, the pursuit of science presents to the human mind an enduring challenge on an endless frontier, typified in the challenge which Everest, the Arctic and the Antarctic have presented, and quite apart from any incidental material benefit to mankind. "It is the adventurous spirit which all scientific men need in their pursuits", wrote Sir Francis Younghusband. "The human race will never be satisfied until it has completed its knowledge of its surroundings."

It is not simply, however, for this testimony to the cultural and human value of science that Sir Edward's address is so welcome. A. N. Whitehead

has pointed out how much the development of science has owed to the antecedent generation of faith in the possibility of science as an unconscious derivation from medieval theology. Mill pressed home a like argument when he insisted that unless an elementary knowledge of science was diffused among the public, they never knew what was certain and what was not, and either had no faith at all in the testimony of science or were the ready dupes of charlatans. Sir Edward's plea for science for its own sake should stimulate fresh and constructive thought on the teaching of science and training of scientists, and especially on the use of science as a vehicle of liberal education. It should equally encourage the pursuit of science for its own sake, by the amateur as well as the professional; this could go far to promote a public understanding which in these days is increasingly essential, both to ensure adequate public support and to secure the conditions in which scientific investigation is most fruitful.

MERSEYSIDE

A Scientific Survey of Merseyside

Edited by Prof. Wilfred Smith, assisted by F. J. Monkhouse and H. R. Wilkinson. Pp. xv+299+8 plates. (Liverpool: Published for the British Association by the University Press of Liverpool, 1953.) n.p.

THE British Association is to be congratulated in having brought out ten days in advance of its meeting in Liverpool a "Scientific Survey of Merseyside": no member attending this year's meeting can afford not to study this handbook for the background knowledge that it gives if he wants to make full use of his stay in Liverpool. The book follows the same lines as those of previous years in being not only a scientific but also a historical, sociological and, in general, cultural review of the district. It is composed of three parts, each roughly a hundred pages long, devoted respectively to the "Land and the Sea", "Merseyside" and "Merseyside District", and each part contains about ten separate articles written by experts in the particular fields. The co-ordinating editor is the John Rankin professor of geography in the University of Liverpool, and the two assistant editors are also in the Department of Geography of the University. It can be said of this book, and rightly so, that the method of compilation is fragmentary, with inevitably some overlap between the fragments, but it can equally be said that the multiplicity of authorship ensures that each section bears the stamp of authority; also, since the volume is produced primarily for the members of the British Association, whose interests are indeed manifold, any one member can find in this book a succinct account of the aspect of Liverpool that appeals to him most, and the rest of the book can be read more casually. Anyway, the fact that the Association always produces this type of handbook in this particular way must surely be proof that it is the method which its members prefer.

Being specialized, the articles are varied in content and approach, but one feature runs right throughout a large number of them: the development of the district has been essentially coastal and, more especially, has been built up around the estuaries of first the Dee and afterwards the Mersey. The history of England is very much the history of its coasts, and it has often happened that important ports were developed which in later years silted up and lost their pre-eminence to another, often lesser, port that was more favourably situated. So too, from the days of the Roman occupation until the Middle Ages, Chester was the great town for the area and the Dee was the source of its strength. By contrast, the Mersey was a large dangerous river, unsheltered and with strong tidal currents, and Liverpool was a hamlet of no consequence, the first mention of its name "Liverpul" (the etymological derivation of which is uncertain) being in an undated charter of about 1190. As the Dee silted up, attempts were made to establish harbours downstream of Chester, but of no avail, and to-day Chester's maritime greatness merely survives in the tradition that its Mayor holds the office of Admiral of the Dee and his symbol is an oar.

Liverpool's population grew from approximately 5,000 in 1700 to 20,000 in 1750 and 53,853 in 1790, this last figure being determined by an official 'scrutiny'. The increase continued unchecked throughout the nineteenth century so that by 1931 the four county boroughs of Merseyside—Liverpool, Bootle, Birkenhead and Wallasey—had a total population of 1,183,000 with 208,000 in the surrounding districts. The very great concentration of inhabitants probably represents a peak, for in 1951 the corresponding figures were 1,108,000 and 359,000, respectively. The decrease in the central population was mainly experienced by Liverpool itself, which had 62 per cent of the total in 1931 but only 54 per cent in 1951; thus there has been a general trend away from the crowded centre, a trend which was materially accelerated by the bombing during the Second World War and the subsequent rehousing of the people in new estates built outside the city boundaries.

It is the aspect of its population which makes Merseyside a fascinating study for the sociologist, and the scientist and historian as well—the phoneticist alone has a rich field, as anyone who has listened to "Frisby Dike" on the B.B.C. will readily acknowledge. A number of the articles of the handbook, each well furnished with statistics and diagrams showing geographical distribution, discuss the multiplicity of race; and a feature that is very apparent is the strong connexion that Merseyside has with the people living in the comparatively narrow fringe along the northern coast of Wales from the Dee to well-nigh the tip of Caernarvonshire.

Of the rest of the contents of the book, space precludes but a mere mention of one or two points. Thus there are descriptions of how the Mersey became a suitable harbour by the creation of docks, the first one being opened in 1715, and how, with the coming of steam, the ferry services improved, leading to the growth of Birkenhead and Wallasey. Then there is the mineral wealth of the country—the salt deposits of Cheshire and, more important, the coal mines, linking up with the great industries of Lancashire; again, the advent of steam, in this case in the pumping of the mines and later in the development of railways (witness the famous Liverpool–Manchester line) ensured that Liverpool would be an outlet for a great industrial hinterland. Finally, there is the University of Liverpool itself, which this year celebrates its jubilee; it is fitting that the British

Association should meet this year in the precincts of an institution which, for fifty years as university and for long before that as a university college, has been in the forefront of science and learning of all kinds.

MILNE ON JEANS

Sir James Jeans

A Biography. By the late E. A. Milne; with a Memoir by S. C. Roberts. Pp. xvi+176+2 plates. (Cambridge: At the University Press, 1952.) 21*s*. net.

THE Syndics of the Cambridge University Press, which had published most of the books, both technical and popular, written by Sir James Jeans, wished after his death to publish a biography of him. In consultation with Jeans's executors—of whom one was then secretary of the Press (Mr. S. C. Roberts, now Master of Pembroke College, Cambridge)—Prof. E. A. Milne was invited to write the book, and agreed on condition that his should be the final voice on any question as to its contents that might arise between him and the Syndics or executors.

Milne finished the book some months before his own untimely death in 1950. It is of moderate length, and is almost equally divided between six biographical chapters and six dealing in some detail with Jeans's varied achievements. There is also a bibliography (and a somewhat faulty index) and two excellent photographs of Jeans in middle life—more photographs at other ages would have been welcomed by many readers.

Eddington, though younger, died before Jeans, in 1944. He, Jeans and Milne engaged in notable scientific controversies at the Royal Astronomical Society. In these debates there was all-round mutual criticism; but on the whole Milne sided with Jeans. To the end they differed on the disputed scientific points, but remained on terms of personal courtesy and recognized the greatness of each other's achievements.

Their controversies have echoes in this book, and, as in the life-times of the three men, other scientists may differ from Milne's judgments on parts of Jeans's work—and, incidentally, of Eddington's. The scientific half of this biography is in some places necessarily highly technical, and a section of the large public to which Jeans's popular writings appealed will find themselves at times out of their depth in reading it. But they may also enjoy many passages in it, for Milne himself had a clear, and often vivid, style—though he did not follow Eddington and Jeans in writing for the general educated public.

His scientific appraisal of Jeans's work begins with Chapter 7, on the state of physics in Jeans's boyhood, and proceeds to chapters on five divisions of his work: first on the partition of energy between different wave-lengths, in the radiation from a 'black' body—in this field Jeans derived anew, and corrected, an important formula given by Rayleigh. This work exposed, without solving, the difficulties that were met by the development of the quantum theory. Mention might have been made in this chapter of Jeans's contribution to the older type of kinetic theory of non-uniform gases, in which, by considering the persistence of molecular velocities after collisions, he improved the calculation of the coefficients of viscosity, conduction and diffusion.

Then follow two admirable chapters on the forms of equilibrium of rotating fluid masses, and on the dynamics of star clusters, which describe some of Jeans's most permanent and valuable achievements. The next chapter, on the internal equilibrium of the stars, is valuable but in several points debatable. The final chapter gives a decidedly critical summary of Jeans's incursions into philosophy.

The first six biographical chapters are easier to read and also of great interest. The first describes Jeans's early life, at school and college; his college career was interrupted by a serious illness which took him for more than two years to a sanatorium, where he wrote his original and successful book "The Dynamical Theory of Gases". The second chapter deals with his four years at Princeton, including his first marriage; and the third with the years 1909–19, spent at Cambridge, Guildford, London, and (from 1918) at Cleveland Lodge, Dorking, where he installed an organ for his own use, and where he lived thereafter, except for a time during the Second World War. Chapter 4 covers the decade to 1929, in which he exerted much influence as secretary of the Royal Society, while still continuing his scientific researches, one main fruit of which was his recognition of radiative viscosity. Chapter 5 relates how he was led to turn from research to popular exposition, which brought him widespread fame and added wealth. The last fifteen years of his life occupy Chapter 6; the loss of his much-loved first wife, and the illness of their only child Olivia (who did not long survive her father), sadly beclouded his seemingly bright fortunes.

In these biographical chapters Milne attempted no account of Jeans's complex and interesting personality. Unlike some men who devote themselves to deep and difficult researches, Jeans was no recluse; he mixed freely and widely with his fellow scientists, and was a good man of business, yet he was shy and lonely. He showed many personal kindnesses, and enjoyed appreciation and friendliness from his colleagues and others; but he found it very difficult to disclose his deeper feelings and allow intimacy to grow. The book is therefore much enriched by the seven-page "memoir" in which Mr. Roberts describes how friendship developed between him and Jeans after the death of the first Lady Jeans; and of how, a few years later, this aloof, constrained 58-year-old widower, through his love of music, won a charming young wife, and renewed happiness in a marriage blessed with the family cares and companionship of three young children.

SYDNEY CHAPMAN

SIR EDWIN CHADWICK, THE SOCIAL REFORMER

The Life and Times of Sir Edwin Chadwick

By Prof. S. E. Finer. Pp. xi+556. (London: Methuen and Co., Ltd., 1952.) 42*s*. net.

THIS clearly written book can be recommended to all who are interested either in the social or administrative history of England and to those who wish to know more about the early struggles of social scientists in Great Britain. So far as historians are concerned, the value of the book is obvious, for the development of the social services, and of the administrative institutions connected with them, is

a most important aspect of English nineteenth-century history. The capitalist phase of the English industrial revolution cannot be properly understood without a detailed knowledge of the organization of the 'poor law', and the slow growth of the public health services. Edwin Chadwick was so much involved in their development that the history of social administration in the two middle quarters of the nineteenth century is largely the story of his public life. The relevant material has been assembled with great care by Prof. S. E. Finer and analysed with skill. As a result, the story he recounts of important events such as the "Andover Scandal" will be read with pleasure as well as with profit, for it throws much light on the underlying political and social trends of the times, and it is also a complete human drama in itself.

Even more important, however, Prof. Finer's book can be regarded as a case-study in the most important field of the relationship between social structure, individual behaviour and technological change. The opening chapters of the book describe the ways in which the scientific techniques of the day were applied to the study of social problems and the consequences that followed from the personal and emotional involvement of a number of important individuals in the complicated social processes of 'poor law' reform. Chadwick is shown to be a clear-thinking man of action, whose somewhat naïve endeavours seem almost to have been calculated to arouse the greatest degree of opposition in whatever situation he was placed. This remarkable phenomenon became even more plain when he was forced out of 'poor law' administration and entered that of public health. He was usually right; but the more the facts were on his side and the more reasonable his interpretation of them was, the greater the degree of resistance he encountered. His battle with the sanitary engineers on the issue of the self-cleansing earthenware pipe versus the man-sized brick sewer may well turn out to be a classic example of the folly of endeavouring to change a situation in which the lives and the interests of many intelligent and experienced people are deeply involved, by a frontal attack merely designed to demonstrate the unsoundness of their views.

Social scientists and administrators have moved a long way since Chadwick's day, but his example and experiences are still of significance to the practitioner as well as the student.

T. S. Simey

MINERAL NUTRITION OF PLANTS

Mineralstoffe und Pflanzenwachstum

Von Prof. Dr. Walter Baumeister. Pp. viii+176. (Jena: Gustav Fischer, 1952.) 12 D. marks.

ALTHOUGH the processes involved in the organic and in the inorganic nutrition of plants are closely related and interconnected, they are often, and indeed usually, considered as separate aspects of the physiology of plants. This is very understandable and reasonable, for the methods used to examine the problems of the assimilation of carbon into the plant from the air are generally quite different from those that have been evolved for the investigation of the absorption of the mineral constituents of the plant from the soil and the fate and function of these constituents in the plant.

As a result of the vast amount of work which has been published on the mineral nutrition of plants since Liebig, working in the latter part of the first half of the nineteenth century, laid the foundations of our knowledge of the subject, we now have a considerable, if still inadequate, mass of information on the processes concerned in mineral nutrition. It is therefore rather surprising that only a very few attempts have been made to present a general view of the inorganic nutrition of plants. Prof. W. Baumeister's attempt to do this is therefore all the more welcome.

After a brief historical review of the subject, there follows a section on the significance of the mineral elements for the plant. This indeed takes up more than 90 per cent of the whole work; the succeeding sections on the significance of soil reaction for the distribution of plants, the physiological significance of the elements and their position in the periodic system, and the maintenance of nutrients in the soil and harvest yield, together occupy only eight pages.

The main section of the book opens with an account of methods, including descriptions of the water-culture and sand-culture methods and field-trial techniques. These are on the whole satisfactory, but one must take exception to the unqualified statement that aeration of water cultures is generally not necessary for higher plants. While it is true that plants of many species will survive in unaerated water cultures, it has been known for many years that lack of aeration may affect very adversely the rate of growth of plants of many species in water culture.

The facts and theories of the absorption of mineral constituents by the roots are usefully and succinctly dealt with, and there is a very brief summary of the mineral content of different kinds of soil and a longer account of the mineral content of plants. The parts played by the individual mineral elements, including nitrogen and the trace elements, are considered in much more detail. Here the ground is on the whole well covered, although there are a few rather surprising omissions. Thus, in dealing with the physiological significance of copper there is no mention of the copper enzymes, nor is there any reference to the presence of zinc in the enzyme carbonic anhydrase. However, in spite of these omissions, the book presents a balanced and reasonably concise review of the subject of the mineral nutrition of plants and should prove useful for students of plant physiology.

W. Stiles

HUMAN ECOLOGY

Les fondements de la géographie humaine

Par Prof. Max. Sorre. Tome 3: L'Habitat; conclusion générale. Pp. 500. (Paris: Armand Colin, 1952.) 1500 francs.

THIS is the third and last part—actually the fourth volume since the second part was issued in two volumes—of the great work which, for many years, has occupied Maximilien Sorre, professor of geography at the Sorbonne, vice-president of the International Geographical Union, and aptly described now as the *doyen* of French geographers.

He points out that it is the practice of naturalists to use the word habitat in a very broad sense, covering both a general environment such as a 'steppe habitat' and also the precise local conditions of an actual place. Normally, geographers tend to draw a distinction between 'habitat' in the broad sense and 'habitation' applied to an individual home. Sorre

deliberately takes the widest possible meaning and hence leads from the general concept of the *œcumene*, or habitable part of the earth's surface, through the varied types of rural habitat, to the growth of towns and the great cities considered as environments wherein human beings pass their lives.

The field is vast in both space and time, and the bibliographies attached to each of the thirteen chapters show how widely the scattered literature has been studied, especially that of France, Germany, Britain, the United States and Italy. The bibliographies alone would render this work indispensable to the serious student of human geography, but the care with which the author has sought his material is matched by the care with which he has set out his findings. A laudable feature is the separation—in the case of the rural habitat into two separate chapters—of facts and theories. While much of the material on towns lies perhaps in the general field of sociology, an interesting chapter is devoted to large towns as a human *milieu* in which features of the local and micro-climates are examined. In another chapter the functions of a town are considered under three headings—social (listed as military, spiritual and political), exchange or commercial, and industrial. Among the difficult questions which inevitably arise are the definition of a town and the contrast with an overgrown village, the problem which has so much exercised town planners in recent years—the definition and delimitation of urban hinterland or *Umland*.

In the general conclusion to the whole work, which occupies the last forty-five pages of this volume, Sorre takes up briefly the vexed question of the natural region and its definition, and so leads to those areas of the earth's surface which have cradled the great civilizations of the past as well as of more recent times. He proceeds finally to the distribution of man on the habitable earth, noting the present-day development of power as a great localizing factor. The growing pressure of population on space he leaves, presumably, for his successors to worry about.

One would have liked more text-figures, since the thirty-two given, though appropriate enough, are all from familiar sources. So much scholarship deserves a better index: no authors are listed in the six pages devoted mainly to indexing places. On the other hand, a useful subject analysis to the four volumes is included. Proof-reading, especially of foreign authors' names and titles of books and papers, leaves something to be desired; but these are minor blemishes in a work of great value.

L. Dudley Stamp

MOLECULAR ARCHITECTURE

Die Struktur des freien Moleküls

Allgemeine physikalische Methoden zur Bestimmung der Struktur von Molekülen und ihre wichtigsten Ergebnisse. Von Prof. H. A. Stuart. (Die Physik der Hochpolymeren, Band 1.) Pp. xxi+609. (Berlin, Göttingen und Heidelberg: Springer-Verlag, 1952.) 69 D. marks.

THIS is one of a series of four volumes by different authors designed to describe the physical architecture and properties of high polymers. But since polymers are built up out of smaller units, it is natural that the first volume should be concerned with the structure of a free molecule of not more than twenty or thirty atoms, and with the type of experiment which can be made to provide information about this structure.

Let it be said at once: this is a massive effort. The six hundred pages are literally packed with tables of numerical values, varying from interatomic distances and force constants for vibration to polarizability tensors and Kerr constants. Few people can boast such a wide experience in the physical behaviour of molecules as H. A. Stuart, now professor of physics at Hannover. It has been his intention to include between the two covers of this one volume every known approach to the study of molecular structure. The result of his efforts is something unlike any other account at present available. It will inevitably become a standard reference work for a good many years to come.

One is tempted to compare the present book with the well-known accounts by Prof. G. Herzberg, since these are the only comparable discussions of molecular structure on anything like the same scale. There is much less overlapping than one might have thought. This happy situation results from the different approaches of the two authors. Herzberg is interested in the internal structure of a molecule, and he is always asking: Why is this as it actually is? Stuart is chiefly concerned with discovering what the properties are, and with systematizing them, but without any desire to 'explain' them. If all reference to wave mechanics were removed, Herzberg's books would be mauled almost beyond acceptance; Stuart's book would scarcely be affected. For Schrödinger's name does not even appear in the author index, nor can wave mechanics be found in the subject index. The wave equation itself appears merely in a footnote, and then only in relation to the description of a highly simplified molecular system. Herzberg gives elaborate descriptions of molecular states; Stuart covers the electron classification in molecules in a couple of pages, and dismisses resonance in about the same space. But, for tables of dipole moments, the latest microwave results for bond-lengths, the polarizabilities of molecules and of bonds, depolarization factors, molecular association and intermolecular forces, the reader will look to Stuart and not be disappointed. The literature is exceedingly well covered, up to about 1950: when one realizes the extremely wide variety of fields under review, this is a quite remarkable achievement. Perhaps I was unlucky; but I found no less than five minor mistakes in the references in about half an hour's test.

As might be expected from such an author, there is a great deal of emphasis on the sizes of atoms and ions; and a great deal of information about the scattering of light by small, and large, molecules which is not easily found elsewhere. There are certain notable omissions, such as to the work of Ingold on the structure of benzene, and to the famous Jahn–Teller theorem on the stability of molecules with degenerate energy-levels. In one or two places, such as the ultra-violet absorption of polyenes and the free-electron model, the account seems to me rather inadequate; in one or two others, such as the old and larger value for the dissociation energy of F_2, it is a little out of date. But these are all relatively minor blemishes in a book which admirably serves its purpose of describing particularly those physical aspects of molecular structure which are relevant to the subsequent study of high polymers.

C. A. Coulson

BRITISH ASSOCIATION MEETING AT LIVERPOOL

SCIENCE FOR ITS OWN SAKE

By Sir EDWARD APPLETON, G.B.E., K.C.B., F.R.S.

PRESIDENTIAL ADDRESS

IN expressing my warm appreciation of the signal honour of being elected the Association's president, I would like to add how particularly agreeable the occasion is made for me by the fact that our meeting this year takes place in Liverpool. In my younger days all my journeys by sea began at Liverpool which thereby came to represent for me a gateway to adventure; and something of the old magic still remains.

Now, although our Association met four times in Liverpool before the University was founded, in the two succeeding Liverpool meetings the University has joined with the City in welcoming our members and organizing much of our week's activity. Our reception by 'town and gown' has been, on this present occasion, notably graceful and gracious, and I would like to tell both the Lord Mayor and the Vice-Chancellor how touched we have been by the cordial expression of their greetings and good wishes.

There is, I think, something very appropriate in our meeting here in Liverpool, a city whose interests and history have been so long and so closely bound up with the advancement of science. This happy conjunction has been remarked on by several of my predecessors and has been a fruitful source of inspiration to them. I have noticed, on looking through their addresses, how often their thoughts have turned towards the practical achievements of science and how often they have been able to cite their instances from Liverpool itself. It is interesting to note, too, how the city has served, through successive meetings, to point the direction which science was to take. The great developments that were noticed here by the Earl of Burlington at the first Liverpool meeting in 1837 were an indication of many things to come in other parts of the country before the turn of the century. Indeed, one might say that what was true of Liverpool at one British Association meeting was true of the rest of Britain at the next, and of most of the world by the one after that.

I confess that I stand somewhat in awe of my distinguished predecessors, who were inspired by this setting to range so widely over the fields of scientific progress in their own day. To succeed to an office which has been held here in Liverpool by such men as Rutherford and Lister and Huxley can be no easy task. It is not only the abilities of these men which now appear outstanding. What has particularly struck me, on reading their words, is the story of solid achievement each had to relate in speaking of recent scientific progress. "The heroic age of physical science" Rutherford appropriately calls the period that saw the first investigations of the radioactive elements, the discovery of X-rays and the development of wireless telegraphy. And, again, speaking of the period between the two Liverpool meetings of 1896 and 1923, he remarks "the epoch has been an age of experiment when the experimenter has been the pioneer in the attack on new problems. At the same time, it has also been an age of bold ideas in theory, as the Quantum Theory or the Theory of Relativity so well illustrate". Joseph Lister, at an earlier meeting, dwelt in his address on the same conjunction of experiment and theory, and how their application in the field of medicine had led, in his own time, to the ever-memorable discoveries of anæsthetics and antiseptic surgery. A similar sense of substantial achievement is conveyed in the words of T. H. Huxley. Devoting himself to a theoretical account of the genesis of bacteria, he nevertheless pauses in it to estimate that the practical applications of the theory, in the French silk-worm industry and wine trade alone, had—to quote his own words—"repaired the money losses caused by the frightful and calamitous war of this autumn"—he was speaking in 1870. In Huxley's remarks, indeed, I seem to detect a certain diffidence about entering the realm of pure theory at all, for, after apologizing to his audience for the dreariness of the theoretical approach to his subject, he continues: "Nevertheless you will have observed that before we had travelled very far upon our road, there appeared, on the right hand and on the left, fields laden with a harvest of golden grain, immediately convertible into those things which the most sordidly practical of men will admit to have value—namely, money and life."

What my predecessors had to tell was indeed a story of outstanding achievement. Yet what those great men had to say about the benefits of science can surely be equalled, if not surpassed, in our own day. It is true that nowadays we are more sharply aware of the debit, as well as the credit, side of our accounts with science, as my predecessor, Prof. A. V. Hill, reminded us last year. But no one could doubt that the material benefits of science are there and, indeed, are with us in our daily lives to an extent which even the nineteenth century could scarcely have expected.

Now the subject of my address, "Science for its own Sake", is already known to you. It was chosen to emphasize something that, at times, is in danger of being overlooked, namely, that science has interest as well as utility—that science is illuminating as well as fruitful. Having spent ten years of my own life in seeking to further the applications of science in the practical life of our country, I do not think I can be accused of under-estimating the vital importance of science as an instrument of material utility. I have long held the belief that the cost of scientific research is the price we must pay for our industrial progress. But we should be misleading the public, as well as ourselves, if we based our case for the general support of the pursuit of science on its utilitarian aspects alone. I know that we can claim that many discoveries in pure science, which in their time had

no obviously practical import, have later proved to be the foundations of major improvements in our material civilization. But even that is an argument of profit and loss, and, to my mind, does not bring us entirely to the heart of the matter. I should like to go back, beyond the achievements, to the example of the scientist—be he amateur or professional—who is impelled solely by a passionate desire to explore and understand. That is what I mean by science for its own sake—when knowledge and insight are sufficient reward in themselves. Can the pursuit of a scientific vocation of this kind be a way of living worthily? Can it, in Dr. Johnson's phrase, help to advance us in the dignity of thinking beings? What values for us as individuals does it propound? As well as theoretical knowledge, as well as material benefit, is there some deeper, if more intangible, thing, even wisdom itself, to be found in our vocation?

I certainly make no claim to be able to provide the right, or the only, answers to such questions. At the most I simply hope to indicate to you where I think *some* of the value of a scientific vocation lies. After the extravagant claims that have sometimes been made on behalf of science—claims which have had the disagreeable consequence of putting the scientist on a pedestal—it is well that we should walk humbly. Yet, all the same, in a time of uncertainty of values and lowering of ideals, it is important that we should own to what we believe.

Now I begin by attempting to get the setting right, by pointing out that we scientists do not really inhabit the kind of universe which has sometimes been attributed to us. Science has so often been accused of having reduced the beauty and mystery of the universe to something cold and mechanical. When science enters the door, enchantment, it has been said, flies out of the window. You will remember the lines of the poet Keats:

> "There was an awful rainbow once in heaven:
> We know her woof, her texture; she is given
> In the dull catalogue of common things."

Now it is fairly easy to see how this attitude came about. The world of what is now called classical physics, as it was mapped out for us from the time of Newton onwards, had the advantage of appearing comfortably solid and tangibly final. Anyone, it seemed, who could understand why an apple falls from a tree could also understand the stars in their courses. In this light the universe might well seem to a poet to fail to come up to his expectations. We now know how misleading it was to regard this account of the matter as final. Perhaps the most striking fact about modern science, in its explorations ranging from the heart of the atom to the frontiers of the universe, is that, like poetry, like philosophy, it reveals depths and mysteries beyond—and, this is important, quite different from—the ordinary matter-of-fact world we are used to. Science has given back to the universe, one might say, that quality of inexhaustible richness and unexpectedness and wonder which at one time it seemed to have taken away from it. "The world will never starve for want of wonders," says G. K. Chesterton, "but only for want of wonder."

I hope to try to illustrate all this in a moment from the fields of cosmical research which have been my own interest for many years. But just now one general point I want to emphasize is that the scientific approach to things is a far more personal and imaginative activity than is sometimes realized. I am ready to admit that deliberate application to discovery can often take us some distance; also that important progress can result from the operation of a team of workers, as distinct from an individual, though this is mostly the case when the follow-up or consolidation of a basic discovery is in question. But the big jumps ahead are usually the adventures and intuitions of a single mind.

I need scarcely remind such an audience as this that scientific activities are twofold. We can make observations and experiments—that is to say, gather facts. We can also seek to understand how the facts fit together. We express any order we can discern among the welter of facts in the form of a hypothesis or a theory. A theory, by the way, is only a hypothesis that has become, so to speak, respectable. But even then there is nothing final about it. As J. J. Thomson once said, a theory is a policy rather than a creed.

Now, even in this question of making observations, the scientific process is one which requires the fullest and subtlest employment of all our faculties. It demands, for example, that we should not only see things, but should also notice them; and not only notice, but also perceive them. Many a vital discovery has been nothing else than recognizing the unexpected. To encounter Nature in this necessary state of awareness is inevitably to find all its forms and movements, from the infinitely small to the infinitely large, full of inexhaustible significance and relevance. But even in experimental work it is the primacy of an imaginative idea or intuition that often starts it all off. In simple words, I might say that the important thing in experimenting is to ask Nature the right question and in its more direct form. Only then is the answer clear and unmistakable. But so often one has failed to ask the right question and the terms of it have to be recast. In this complex process it is as if knowledge were playing a game of chess with the mind, and one has to be constantly on the alert with fresh tactics or even a changed strategy.

Many of our questions turn out to be wrong because they are unanswerable, but it is only by asking them at all that we eventually find we have asked the right one. One knows how oddly, how unreasonably I might almost say, the right question has often flashed into men's minds. It was recorded by the German physicist Helmholtz that his best ideas only came to him when he was walking slowly up a wooded hill—and significantly enough he was one of the founders of the principle of the conservation of energy! What I do know, from my own experience, is the fruitlessness of pondering over a scientific problem too long. The mind gets polarized and thought becomes captive to a groove. How often the best way of solving a scientific difficulty is to leave it alone! Also, speaking as a professional scientist who has only recently turned amateur, I would like to acknowledge the immeasurable debt which science owes to members of the latter category. My own subject of radio-physics has, on many occasions, been advanced by the observations of the gifted and enthusiastic amateur who was able to recognize the unexpected, even if his professional skill was insufficient to enable him to reveal its full meaning and implication.

Asking Nature the right question in the right way—or recognizing a theoretical pattern in a tangled

skein of experimental data—often has the effect of introducing an element of beauty and elegance into the scientist's work. Do we not, on occasion, refer to a 'beautiful theory' and an 'elegant experiment'? It is perhaps a little difficult to say what precisely we mean by this. Not, I think, that the theory or the experiment is necessarily conclusive or irrefutable, or even particularly fertile in its consequences—that would be virtue of another kind. The quality I have in mind is that of inevitability—and yet, paradoxically enough, an inevitability which can cause surprise. A great experiment seems to us, somehow, something which could not have been done differently. Or, if it had, something essential would have been lost. We are surprised that someone thought of doing it that way, but we can see now that that way is really the only way to do it. Taking away something, or adding something, only detracts from it. In this respect a beautiful experiment can surely be classed with a great work of art.

Now I have spoken in general terms of the scientist's approach to Nature and of the kinds of mental quality and awareness that science requires in its followers. Also I have tried to suggest that the exercise of these skills has a value in itself which is ample justification of a scientific vocation. To go further might be claiming too much. Yet, I wonder. If we think of the great figures of science and, to be fair, restrict ourselves only to those we have known intimately, can we not go further and say that the scientific vocation, by its very nature, calls for personal qualities that deserve to be recognized and honoured? I might point, for example, to that tolerance and open-mindedness to new ideas which shines even from the printed page of Rutherford's address to this Association when he was president here thirty years ago—that freedom from prejudice, muddle, hypocrisy and darkening of counsel which characterized the man many of us were so privileged to know.

Yet, in less serious vein—a vein to which Rutherford was as much addicted as anyone else—ought we not, as scientists, to try to see ourselves as others see us? Joseph Addison once declared that there was this at least to be said for natural philosophy, that it occupied the attentions of men, who, if they had pursued public affairs and politics with equal zeal and vigour, would have set the whole country aflame. While Dr. Hartley in his "Observations on Man" declares that "Nothing can easily exceed the vain-glory, self-conceit, arrogance, emulation, and envy that are to be found in eminent Professors of the Sciences, Mathematics, Natural Philosophy, and even Divinity itself. Temperance in these studies is, therefore, evidently required, both in order to check the rise of such ill passions, and to give room for the cultivation of other essential parts of our natures." Yet Adam Smith, in his "Theory of Moral Sentiments", finds far more to say in our favour. "Mathematicians and Natural Philosophers," he says, "from their independency upon the public opinion, have little temptation to form themselves into factions and cabals, either for the support of their own reputation, or for the depression of that of their rivals. They are almost always men of the most amiable simplicity of manners, who live in good harmony with one another, are the friends of one another's reputation, enter into no intrigue in order to secure the public applause, but are pleased when their works are approved of, without being either much vexed or very angry when they are neglected. It is not always the same case with poets, or with those who value themselves upon what is called fine writing." I only hope we scientists can see ourselves in that mirror.

For specific examples of what I have called the pursuit of science for its own sake there is, of course, no shortage of material on which to draw. I have, however, decided to tell you the story of only one field of development to-night—a long short story if you like—instead of a number of short stories in brief outline. My story has been selected because it bears on what men think about the world rather than what they do about it, for it concerns the nature of certain objects in outer space the nature of which has only been revealed in recent months. If I required a more homely title for my story it would be "Finding things out about places we can't visit".

From time immemorial men have examined the sky with their eyes, and found it to be populated with luminous bodies, the stars shining with their own, and the planets with borrowed, light. As time went on, telescopes were used to assist the naked eye, and in this way it was possible to see more feeble and more distant stars. Generally we may say that the bigger the telescope the more powerful it is in helping us to plumb further into the depths of space. The 200-inch telescope at Mount Palomar can detect stars so far away that it takes the light from them 1,000 million years of travel to reach us. In such cases the human eye is supplemented by the photographic plate which, through prolonged exposure, permits the photography of faint objects which can never be detected by the eye alone. In addition to the telescope the astronomer has also looked at stars with a spectroscope, by which the light from the stars is analysed into its constituent colours. In this way it has been possible to identify the kinds of atoms which exist in stars; since we know, from experiments carried out on the earth, how to recognize particular atoms by the particular colours—or wave-lengths—of the light they give out. We can call all observations of this kind optical astronomy since, in making them, we examine the optical light which comes from the stars.

Now it is of great interest to us here in Liverpool to-night to recall that it was Sir Oliver Lodge, one of the first professors in the University of Liverpool, who first thought of looking at the heavens with a "radio eye" instead of with an "optical eye". The year was 1900, in the earliest days of radio, and Sir Oliver tried to discover whether he could detect radio waves from our own particular star, the sun itself. The experiment failed because of the insensibility of the wireless receiver used—it was the day of the coherer. Yet it would be no misnomer to call Sir Oliver the first radio-astronomer, for the experiment was surely conceived on right lines and, with modern valve equipment, would have commanded success.

However, it fell to an American radio-engineer, the late J. G. Jansky, of the Bell Telephone Laboratories, to discover that radio waves, as well as light waves, could be received from the heavens. One interesting feature of this discovery was that Jansky found all this out when he was looking for something else. But with impressive scientific awareness he was ready to recognize the unexpected. Jansky was primarily studying the direction of arrival of atmospherics, but he noticed a persisting hiss in his ear-phones when his directional aerial was aligned to receive from a particular direction, which he later showed

was the direction of the stars in the Milky Way. The year was 1931.

Jansky, appropriately enough, was the first person to speculate on the origin of this radio noise from outer space. He pointed out that the most obvious explanation was that the radio waves came from the stars themselves and that we get the radio noise in strength from the Milky Way because a great population of stars is concentrated there. But when he came to test his hypothesis by looking for radio waves from our nearest star, the sun, he obtained a discouraging result. For, even with the equipment available in his day, he found, like Sir Oliver Lodge, that no radio waves were detectable.

Now it is one of the remarkable features of the history of this subject that Jansky's researches incited only a few sporadic observations in the way of repetition. During the Second World War, however, radar operators, using their sensitive equipment operating on wave-lengths of 5–10 metres, so to speak re-discovered the phenomenon. But that was a period when one had to distinguish sharply between the scientific things that were only interesting as distinct from the things that were really useful. Quite a number of other matters of purely scientific interest arose in the same way, but all one could do was to note them and shelve them until the War was over.

I can well remember how these various topics cropped up, during the War, in the discussions of a panel of young scientific workers of which I had the good fortune to serve as chairman. This panel was really a small sub-committee, though it had a long name* and a distinguished parentage. It used to claim that, unlike most other war-time committees, its membership was confined to scientific workers and did not include officials. That I might have been classed in the latter category was generously overlooked. The task of the Ultra Short Wave Panel was to examine and interpret all the manifold vagaries of radar transmissions which were reported to it from operational experience and from *ad hoc* experiments. The Panel had to concern itself with many things, including, for example, the profound influence of the weather on radio wave travel in the lower atmosphere. The foundation of a new subject, that of radio-meteorology, was one result of its labours. That was a matter of practical moment. But the odd bits of information on radio-astronomy, though choice delicacies for a scientific appetite, had to be renounced. I have in mind here, in addition to the detection of radio noise from the Milky Way already mentioned, such subjects as the radar detection of meteors or 'shooting stars' and the detection—for the first time—of radio waves of violent intensity coming out of sunspot regions on the face of the sun.

Soon after the War, however, these matters became the objects of further inquiry, and it is of much interest to note that radar equipment, developed in the first instance for the detection of aircraft and ships, proved extremely useful for this purpose, requiring only minor adaptations. Dr. J. S. Hey and his colleagues, S. J. Parsons and J. W. Phillips, for example, made the first really detailed investigation of the amount of radio noise coming from different parts of the sky. For this purpose they converted a war-time radar receiver, which had been used in conjunction with anti-aircraft batteries, into a directional radio-telescope. Their work at once confirmed Jansky's original findings and showed that there was a close agreement between the intensity of the radio emission and the distribution of visible stars in the Milky Way.

Now I must digress from my main theme for a moment to remind you of a little of what is known about the distribution of stars in the universe as a whole. Our own solar system is really part of the Milky Way which is, itself, a colony or island of stars in space. This island colony has a structure like a magnifying glass, so that it is circular in shape but thicker at the centre than at the edges. You would not be far wrong if you thought of it as a Yorkshire tea-cake, the currants of which represent the stars. We inhabitants of one of the planets in the solar system do not occupy, however, a particularly privileged position in it, for we are situated nearer to the edge of the island colony than to its centre.

Space is, however, populated with far more stars than are to be found in our own Milky Way. But they are not distributed uniformly. They are grouped in island colonies exactly like our own. The astronomer calls these star colonies extragalactic nebulæ, and, with our big modern telescopes, it is possible to detect between 100 and 1,000 million of them. The average distance between any one of these star colonies or nebulæ and its nearest neighbour is about ten to a hundred times the size of either.

But I must resume my detective story about the radio noise from the Milky Way, for I think you will agree that it sounds much like a detective story as one clue after another is followed up. It was natural to assume at first that the radio noise coming from the sky represented the integrated radio effect of the stars in our own galaxy, since such stars are nearest to us. Our war-time experience concerning radio noise from the sun helped with the necessary calculations, for one could assume, as a first approximation, that all the stars would act like the sun. However, it turned out that there did not appear to be enough stars in the Milky Way to account for the high intensity of the radio noise. So then, as an alternative hypothesis, it was thought that possibly the noise came from the flying atoms and electrons which we know must populate the space between the stars. This was the inter-stellar matter theory. Unfortunately, here again, there were found to be difficulties. To account for the high intensity of galactic radio noise, when observed on the longer radio wave-lengths, required the ionized gas in inter-stellar space to be at a temperature of 100,000 degrees absolute, a value much too high to be reasonable. Also, we already knew that the inter-stellar material in question is concentrated in a narrow band near the galactic equator quite unlike the wide dispersal of both the stars in the Milky Way and the radio noise. So another theory had to be abandoned.

We had therefore arrived at this position, that the cosmic radio noise could not be accounted for as coming from the visible stars in the Milky Way or from the tenuous material existing in the spaces between the stars. However, this unpromising situation was soon relieved by an experimental discovery which, in its turn, led to others. Dr. J. S. Hey, observing the intensity of radiation from different parts of the sky, noticed that the strength of the radio noise from one particular direction—

* The Ultra Short Wave Panel of the R.D.F. Applications Committee of the Advisory Council for Scientific Research and Technical Development of the Ministry of Supply.

from a region in the constellation of Cygnus—occasionally showed rapid variations in a period of about a minute. At first it was thought that these fluctuations indicated variations in the emission from the source itself, but we now know that the variations are brought about by irregularities in the ionosphere, through which, of course, the radio waves must pass before they reach us on the surface of the earth. We can, in fact, look upon these variations as a kind of 'twinkling' introduced by irregularities in the atmosphere. But the most startling conclusion which could be drawn from these observations was that the source of this variable radio noise must be a very small one. In the case of visual light we all know that we can have a 'twinkling' star—because the star is a small source—but not a 'twinkling' moon.

Attempts were therefore immediately made to find out, by even more refined radio experiments, how big—or how small—in size this radio source in the direction of Cygnus actually was. There is no time to describe to you to-night the apparatus which was used, in Australia and in Cambridge, to test this matter, but I can assure you that both experiments qualify for my adjectives 'beautiful' and 'elegant'. Both sets of investigators announced the same result, that the source in Cygnus was too small to have its size assessed with the equipment used—that is, that it occupied less than a tenth of a degree in the sky. However, in the course of the same experiments, the position of this powerful radio source was fixed pretty accurately. Maps of known stars were eagerly consulted to see if the Cygnus radio star, as we may now call it, coincided with any special visual emitter. The result of this examination was most significant, for it was found quite impossible to identify the radio source with any particular star. Within the region which contained the radio star there were many faint visual stars to be found, but none of them seemed to exhibit any special peculiarities likely to associate them with the very powerful intensity of the radio emission.

Then, other parts of the sky were examined with the same apparatus and a further number of 'point' sources of radio waves were identified. One was found in the constellation of Cassiopeia, which was even more powerful than that in Cygnus. It also could be located with good accuracy. But, here again, there was no remarkable visible object apparent on the star map to connect it with.

It is important to pause here a moment to consider the effect of these observations on our outlook at the time. It was natural to ask a whole series of questions. Could it be that a radio star is always a dark star—and so a new type of object in the universe? If so, could it be that there was a duplicate universe—only to be seen with a radio-telescope as distinct from a visual telescope? As regards the overall phenomenon itself, could it be that the total emission of radio waves from the galaxy might be really the integrated effect of these dark stars, just as the diffuse band of light of the Milky Way arises from the unresolved radiation from distant optical stars? You will see that the tendency of the time was still to think of the radio emitters as being neighbouring bodies and inhabitants of our own galaxy rather than of other, more distant, island colonies or nebulæ. However, a little reflexion will show that we must not rule out the possibility of radio nebulæ, as distinct from individual radio stars, even if we suppose that the greater part of our own radio noise comes from our own galaxy, the Milky Way. Any observer well outside the Milky Way should be able to detect the radio emission just as we, who are situated inside it, can do. Such an argument received strong experimental support when a group of radio-astronomers in Manchester noted a relatively faint, but quite detectable emission, from the Andromeda nebula, which is a neighbouring stellar island colony of our own. Further work, at Manchester and Cambridge, has revealed appreciable radio emission from other nebulæ not far from our own galaxy. It is clear that, in such cases, we are probably detecting their internally generated radio noise from the outside.

But the problem of the much more powerful sources remained. Where were they, why were they so powerful, and were they, basically, radio stars or radio nebulæ? Again it was a case for more refined experiments which would enable their positions to be found with greater precision and give some notion of their sizes. I might mention here, in passing, that workers in Sydney, Australia, under the lead of J. G. Bolton, had already tentatively identified one radio star with the Crab nebula, a diffuse, expanding, cloud of gas which represents the remains of a stellar explosion, visible news of which reached the earth, according to Chinese records, on July 4, A.D. 1054. So this was another radio source, identifiable with a visible object, but it was of abnormal type, the ancient relic of a super-nova eruption.

The real attack on the identification of the two major radio sources, those in Cassiopeia and Cygnus, depended on the more accurate identification of their positions. In 1951 some new determinations were made by F. G. Smith at Cambridge and the results were communicated to the optical astronomers with an invitation to search afresh the parts of the sky in question. In the spring of 1952, a new and intensive optical search was therefore undertaken by Baade and Minkowski, at Mount Palomar, using the 200-inch Hale telescope and the 48-inch Schmidt telescope. As a result of this meticulous search, two entirely unknown objects were discovered in the universe. The Cassiopeia radio source was found to be associated with a diffuse cloud of luminous gas, situated within our own galaxy, and possessed of unique characteristics. The tenuous matter of which it is composed is concentrated in a number of fine filaments which are in the most violent motion. From a study of the colour of the light emitted by different parts of the same filament it is concluded that the velocities of such movement are of the order of several thousand kilometres per second. The origin of this gaseous cloud is unknown, for it seems impossible to regard it as yet another supernova explosion.

The source in Cygnus, which you will remember was the one which first gave the clue to the possibility of radio stars, was found to be an entirely different type of object. Here the source of the radio waves was identified with another exceptional object which is considered to be two island colonies—two extra-galactic nebulæ—in collision. Moreover, the distance away of this compound group of stars is estimated as being such that it requires 100 million years for the light and the radio waves generated in it to travel to us here on the earth. It is rather a humbling thought that it is only during the past sixty years of that travel that human beings have managed to learn how to produce radio waves and receive them. Now when a collision of two nebulæ takes place it is considered that the stars of one island colony will pass

freely between those of the other. On the other hand, the more extensive inter-stellar materials of the two island colonies will meet in collision, which will result in high excitation of the gaseous atoms of which this material is composed. One must suppose that, in both the radio source in Cassiopeia and the colliding nebulæ in Cygnus, the high gaseous velocities give rise to this intense radio emission, although the detailed mechanism by which it all comes about is not understood. These identifications were finally confirmed by observations in Manchester, Sydney and Cambridge using still more refined methods of finding the sizes of these radio sources. The results of all three radio-observatories were gratifyingly consistent and were published simultaneously last December. In all cases it was found that the radio sources examined were definitely much bigger than simple stars and therefore corresponded to the sizes of the objects observed optically.

The accurate location of these radio sources in the universe—we must now, I think, drop the term 'radio stars'—has therefore led to new discoveries of great astronomical interest. Two unknown objects of unique character have been identified in the heavens, as a result of clues from the radio side; and it is to be expected that future accurate measurements of the positions of those cosmic radio emitters will lead, in turn, to the discovery of other visual objects of uncommon types. I should explain that the discovery of these rare objects by direct visual search with large optical telescopes would require quite prohibitive effort. The radio-telescope has therefore shown itself to be an important adjunct to the world's greatest optical telescope. But, in addition, there is a further and far-reaching possibility. It is the astronomer's ideal to reach, with optical ranging, the hypothetical limit of the expanding universe, the distance where the extra-galactic nebulæ are receding from us with the velocity of light. So far he has reached very approximately half-way. But the fact that, already, the second most intense radio source can be detected without difficulty at a distance equal to one-tenth of the maximum distance plumbed by the 200-inch telescope suggests that it may, in time, be possible to detect sources at greater distances by radio than by optical means.

But, in any event, the more detailed radio mapping of the radio sources in the heavens must go on; for, as you will have gathered, we are still without an explicit solution of the original problem which started it all off, namely the rough overall correlation of the distribution of radio noise with the general structure of the Milky Way. Much progress in these matters can, I am sure, be expected from the operation of two large British radio-telescopes. Prof. A. C. B. Lovell's group is constructing a large steerable paraboloid of 250 feet diameter at Jodrell Bank, a station of the University of Manchester, which will be the largest single radio-telescope in the world and available for a great variety of investigations; while the large interferometric radio-telescope, recently completed at Cambridge, for work by M. Ryle and his associates, is already yielding entirely new results in the detailed mapping of radio sources.

The radio-astronomical story is therefore far from being fully told, but even already one can record achievements in these three centres of Cambridge, Sydney and Manchester—partly in competition and partly in collaboration—worthy to be ranked with the greatest feats in the art of experiment.

I have only a few words to add by way of post-script. I have tried to show how science, pursued for its own sake, can enlarge men's horizons and invest the world with deeper significance. As an exercise we can claim it to be one of the most complex and far-ranging of our mental experiences. But we must not forget that there are other values and other experiences. At the opposite pole from our scientific endeavour there are the ways of thought which do not change, whose concern is with what is *not* new, with the things that will not be superseded; and to-day we stand in need of these enduring and sustaining values of the spirit more than ever. We well know that, in the field of science, our work will in due course be probably out-dated and certainly surpassed. At any one moment we may have only a precarious hold on a temporary truth and our consciousness of this ever urges us to seek fresh truths and new understandings. I fear that, in doing so, we may lose sight of other aspects of life which have their values too. For, you know, there is a virtue in contentment, in being satisfied with what we already have, which we shall not learn from science. Our vocation, in other words, cannot be the whole of life, for it cannot satisfy all our needs. Nevertheless, I hope I have represented it fairly as no unimportant or unworthy part of it. For we scientists are specially fortunate in this, that our vocation can never be simply an occupation; it is, by its very nature, more than that—a dedication to an end. It often seems to me that what we lack in the world to-day is not so much the impulse to dedication as the opportunity for it. This, at least, the scientist need never lack; the opportunity is open to him everywhere "to strive, to seek, to find and not to yield". To those words of Tennyson's "Ulysses" I would add the words which Dante, long before, put into the mouth of the same Ulysses, when he encourages his crew to venture with him, beyond the furthest point of the known world:

> "O, brothers," he said, "who through a hundred thousand dangers have reached the West, deny not, to this brief vigil of your senses that remains, experience of the unpeopled world behind the sun. Consider your origin: you were not formed to live like brutes, but to follow virtue and knowledge."

To Ulysses and to Dante "experience of the unpeopled world behind the sun" meant, of course, the adventure of voyaging out into the Atlantic, where the sun set and the world came to an end. To-night, as I have tried to show, the scientist has commissioned the words to take on a different—and, indeed, a quite literal—meaning.

But we must still ask ourselves what it is that urges men to do these things, and our answer must surely be that it is the challenge of it all. Why should anyone want to climb Mount Everest? Simply, I suggest, because it is there—as a challenge of the unknown and the unaccomplished—a challenge to spirit and body, now so gloriously met by Hillary and Tensing. In its different setting, the pursuit of science also presents to the human mind an enduring challenge on an endless frontier, quite apart from the material enrichment of mankind to which it may incidentally give rise. "The work may be hard, the discipline severe," as Lord Rayleigh said on an occasion similar to this, nearly seventy years ago, "but the interest never fails and great is the privilege of achievement."

SUMMARIES OF ADDRESSES OF PRESIDENTS OF SECTIONS

HALF A CENTURY IN GEOPHYSICS

IN his presidential address to Section A (Mathematics and Physics), Sir Harold Jeffreys points out that the developments in geophysics in the twentieth century serve to illustrate some fundamental points in scientific method. The dispute on the age of the Earth had come to a head with Huxley's address of 1869. Helmholtz's contraction theory and Kelvin's theory of the cooling of the Earth had both led to estimates of the age of the order of 20 million years, but estimates from the rates of accumulation of sediments gave about 300 million years. Huxley emphasized uncertainties in the physical data, and incidentally cast doubts on the validity of the use of mathematics that, if accepted, would reduce science to mere cataloguing, since mathematics is the only method of testing whether a hypothesis explains the data. The discovery of radioactivity led to estimates of the ages of rocks, and it now appears that the age of the Earth is at least 2,000 million years and may be 3,000 million years. Radioactivity produces a delay in cooling that accounts for the discrepancy between these estimates and that of Kelvin. The estimate from the accumulation of sediments was wrong because the present rate of denudation is probably several times the average through geological time. It was suggested by Perrin and Eddington in 1920 that the maintenance of the Sun's radiation could be due to the conversion of hydrogen to helium, but a fully described mechanism had to wait for more knowledge of nuclear physics, and was not given until 1939, by Bethe and Gamow. The reconciliation of the results has been due mainly to increased co-operation between workers in different fields and to the development of the consequences of hypotheses far beyond the range of direct verification.

Poisson in 1829 had predicted that a solid should transmit both longitudinal and transverse elastic waves, and attempts were made to identify these with waves sent out by natural earthquakes. These were not successful until 1900, on account of low magnification and insufficient damping of the instruments used. R. D. Oldham achieved the identification, and it is from his work that modern seismology has developed. He also recognized in 1906, from the evidence of travel times, that the velocity of the longitudinal wave drops considerably about half-way to the centre of the Earth. Later work has shown that this corresponds to a central core, almost certainly liquid. The times of the elastic waves are now known to accuracies of order 1 sec. out of totals up to 25 min., and the velocities are known all the way to the centre with, on the whole, corresponding accuracies.

The study of gravity and certain astronomical observations give the Earth's mass and moment of inertia. The velocities of seismic waves yield a relation between pressure and density, and from this relation and the mass and moment of inertia the distribution of density can be found with some accuracy. The mean density of the core is about 10 gm./cm.^{3}, and would be in agreement with the hypothesis that the core is mainly liquid iron under compression. A sharp discontinuity of material is indicated by the fact that it gives strong reflexions. W. H. Ramsey has proposed an alternative hypothesis, that the core is of the same material as the rocky shell, but in a state of pressure degeneracy. This deserves detailed theoretical examination.

Earthquakes occur at various depths, up to about one-tenth of the Earth's radius. The mechanism of an earthquake is that gradually increasing shear stress leads to fracture when it reaches a certain amount. This is a normal process in an ordinary solid but not in any sort of fluid. Present knowledge of imperfections of elasticity does not suggest that it is ever valid to apply the mathematics of viscous flow, in which the rate of deformation is proportional to the shear stress, to materials with such rigidities as we find throughout the Earth's shell. These and other considerations are evidence against theories that require extensive convection in the shell. Thermal changes due to differences of cooling in an ordinary solid provide more hope of an explanation of rise and fall of the land surface and of mountain formation.

Terrestrial magnetism is coming into closer relation with the rest of geophysics than had been the case until recently. In particular, the electrical properties indicated should provide means of checking inferences about the thermal state, and Bullard and others are examining the hypothesis that slow changes of the magnetic field are due to electric currents in the liquid core.

The methods of geophysics are now being extensively applied for investigation of structure at small depths. The original motive was economic; but the methods are now being used for problems of pure geology and geophysics. The British Association, especially through its Seismological Committee and the Committee on the Thermal Conductivities of Rocks, has played a leading part in the increased co-operation between users of different techniques in this field.

ORGANIC CHEMISTRY SINCE 1837

PROF. G. R. CLEMO'S presidential address to Section B (Chemistry) commences with the reminder that, when the British Association first met in Liverpool in 1837, Liebig was among those who attended. Being imbued with a missionary zeal for organic chemistry, then developing on the Continent, Liebig made a strong plea for its advancement in Britain, and his advocacy created such an impression that he was invited to write a report on the application of organic chemistry to physiology and agriculture; largely as a result of the interest thus aroused, the Royal College of Chemistry was founded in 1845. Hofmann was appointed professor, and, inspired by Liebig's conception of organic chemistry, he made the institution a great centre of research.

Hofmann's inspiring prophecies so impressed a fifteen-year old disciple in 1853 that the first coal-tar dye, mauve, was discovered in 1856 by W. H. Perkin when attempting to prepare quinine, and in 1869 Perkin synthesized alizarin, thus fulfilling one of Hofmann's predictions. In spite of Perkin's remarkable success in developing the first industry to be based on research, it rapidly declined after his retirement in 1873 but prospered greatly in Germany. Following Hofmann's return to Berlin in 1865, nine years were to elapse before Roscoe established the

first chair of organic chemistry in Britain at Owens College, Manchester. Under Roscoe's guidance, Manchester from 1857 became the centre for the training of chemists, and almost all the developing provincial centres filled their chemistry chairs with Owens men.

The earlier volumes of the *Journal of the Chemical Society* show that for many years from the middle of the past century much of the work done was inspired by the Hofmann school and laid stress on the importance of natural products. In the 1880's work began to appear from many other centres, but there was not a single school of organic chemistry in Britain to compare with many on the Continent. W. H. Perkin, jun., followed Schorlemmer in Manchester in 1892, and the development of organic chemistry since then in Britain owes a great debt to his school. However, it needed the First World War to shock the country into action on the industrial front; but if Liebig could return to-day he would surely exclaim that Britain "has surpassed all his notions".

Even so, we are scarcely at the beginning of understanding the synthetic methods of the cell whether for good or evil, and here the discovery of the isotopes of carbon and nitrogen especially should assist in the elucidation of what is going on behind Nature's curtain.

As one example, carbon-14 has been employed to gain a deeper insight into the reaction whereby the colourless tyrosine is transformed under oxidative conditions into the black melanin-type pigment such as is found in black hair and also in certain pathological conditions. H. S. Raper first established that tyrosine is converted into 5 : 6-dihydroxyindole carboxylic acid, which afterwards gives melanin. According to Raper's scheme, the carbon dioxide evolved in the reaction comes from the carboxylic group of tyrosine; but when this group is labelled with carbon-14, it is possible to prove that only about half the carbon dioxide evolved comes from this source. It is suggested that the catechol ring system undergoes fission, and this is supported by the fact that catechol itself under similar conditions evolves carbon dioxide.

Probably the greatest problem in the prevention of disease to-day concerns the origin of cancer. Recent statistics show that the incidence of cancer of the respiratory system is increasing in industrial areas, and this naturally focuses attention on the air we breathe. For a long time this has been contaminated by chimney smoke, but in recent years it has been aggravated by the black smoke emitted by buses and lorries which now fairly fill, and frequently foul, our highways. The contents of the filth collected from the air of a relatively clean city like Newcastle has been under examination, and some preliminary results are presented.

FOSSILS AND THE EVOLUTIONARY PROCESS

IN his presidential address to Section C (Geology) on "Fossils and the Evolutionary Process", Prof. T. Neville George points out that fossils, by placing organic change in a perspective of geological time, have illustrated evolutionary theory almost from the moment of publication of "The Origin of Species": first in the graded morphological series, then in the phylogenetic line, and now in the multi-variant lineage of successive populations. Recent palæontological theory has consequently come to show close parallels with evolutionary genetics: the one sees plexiform morphogenetic relationships, the other plexiform genetic relationships, between successional populations. Evolution in both appears less as a series of structural changes than as graded chronoclines in population-cluster. Correspondingly, adaptation among fossils is recognized objectively by continuing phyletic survival, and adaptive response by a systematic modal shift in successive populations; and despite the reputation of palæontologists for speculating along purposive and orthogenetic lines, the modern approach by-passes Lamarckian and finalist hypothesis.

A major problem in most groups of fossils is that of explaining divergent evolution—the orthodox branching phylogenetic tree. Speciation by the breaking-up of clines is not usually evident in fossil series, partly because of doubts about lineage-sequence and partly because of ignorance of the process of clinal disjunction among the marine groups to which the great majority of fossils belong. There are obvious difficulties in unravelling the 'adaptive radiation' of widely free-swimming creatures like cetaceans and ichthyosaurs. Neritic metazoans are more liable to local environmental selection, and disruption of species-range is indicated in fossil series by faunal diastems implying migration.

Systematization of the evolutionary process in fossils is difficult because phylogenesis is continuous, and speciation in geographical space as the product of evolutionary divergence is not to be equated with speciation in geological time as the product of successional change. There arises the notorious conflict between morphological and developmental species, the exemplary 'types' of the one being submerged as incidental individuals in the population-series of the other. The classificatory fragmentation of an evolutionary continuum must rest on a conventional basis, and must record not selected or abstracted units but lineage-segments. The resulting taxonomic model is not easily accommodated in a 'Linnæan' system but must manipulate integrated fields of transient forms.

The conventional taxonomic groups incorporating lineage-segments are never precisely clear-cut and distinct like genetical species recognized on the basis of reproductive isolation. Whether they are called sub-species or species or genera is therefore a matter of terms and not of things. Only when there is evidence of evolutionary divergence in lineage 'cross-sections', preserved on the momentary bedding-plane, may sympatric groups prove speciation and properly be called species. A conventional measure of successional change is usually dependent on the degree of overlapping variation-spread in successive populations; but it is defined only with difficulty, for the spread partly reflects the intensity of selection, which may show marked fluctuations from one 'generation' to the next. Moreover, ecophenotypic contrasts between fossil mussels and oysters have shown the difficulties that arise in attempting to distinguish between divergent and successional groups.

Finally, populations, although in current theory they are the convenient unit for analysis, exist only in the individuals composing them. A persisting problem is that of ontogenetic 'recapitulation', partly answered by interpreting evolution in many cases as having been brought about by mutant rate-genes.

But the apparent 'recapitulation' displayed in clonal astogeny, and the analogous complexities of shell-'recapitulation' in the Foraminifera, continue to be mysterious and await further co-operative studies by the palæontologist and geneticist.

THE MAINTENANCE AND SPREAD OF SEA-SHORE FAUNAS

PROF. J. E. SMITH, in his presidential address to Section D (Zoology), discusses the factors concerned in the maintenance and spread of sea-shore faunas.

Intertidal animals are protected by various anatomical, physiological and behavioural devices against the more obvious hazards of the shore, such as wave buffeting and the environmental changes which accompany the ebb and flow of the tide. These adaptations in themselves do not, however, explain the occurrence on the shore of some species and the absence of others, nor the variations in number and geographical range of different animals. The ability of animals to maintain their numbers through successive generations and to extend their range depends, in fact, not so much on the existence of adult adaptations and of conditions favourable to them as on the successful surmounting of hazards met with in early life. It is apparent, when attention is paid to the biography of individual species, that for each stage of the life-history there are requirements which are critical for population maintenance and dispersal. While these conditions are not the same for all species, there are certain elements of generality in the life-histories of intertidal animals and in the hazards that have to be faced which make possible a review of the principal conditions governing the maintenance and spread of littoral animals and a consideration of their bearing on the character of regional faunas.

The potentiality of a species for population replacement and dispersal is vested primarily in its fecundity and in successful ovulation. The two processes are independently controlled. Fecundity, largely an organismal property, is conditioned by the food supply, though little is known of the quantitative relationship in intertidal animals. Ovulation, on the other hand, is directly induced by measurable physical changes, particularly of temperature. This results in a severe limitation of the breeding season of animals living near the periphery of their temperature-range, leading, in all probability, to a reduction in fecundity.

The early stages of development of intertidal animals may be larval, embryonic, with or without brood care. The assumption is sometimes made that while larvæ serve for the dispersal of a species, embryonic development and brood care are more suited for the maintenance of more locally concentrated populations. The possession by many types of larvæ of adhesive mechanisms by which they resist displacement, the ability of many species to vary their mode of reproduction, and our lack of knowledge of the nature and extent of water movements on and near the shore point the need, however, for further investigation of the general conditions of dispersal of the juvenile stages.

In addition to the more obvious causes of mortality among the young brood, such as unsuitable physical conditions and the attacks of predators, the full effects of which have never been worked out in detail, it has recently been shown, in respect to Atlantic and English Channel water, that the chemical constitution of the different water masses has a direct effect on the course of development and the survival of larvæ. To what extent this may affect the character of shore faunas in different regions is not at present known.

A final critical hazard in the lives of intertidal animals occurs at the time of larval metamorphosis which, in many instances, is critically adjusted to the type of substratum available. Even if a suitable bottom is found, the young brood may be required to make extensive exploratory movements before they finally attain the distribution on the beach favoured by the adult population.

The nature and implication of these and other events, their bearing on the problem of the maintenance and spread of intertidal faunas, and their significance in the defining of the zoogeographical regions of the British littoral fauna are further discussed by Prof. Smith during the course of his address.

THE GEOGRAPHER AS HUMANIST

SOME people take the view that the only phenomena which can legitimately be regarded as geographical are those which show definite evidence on the earth's surface; but such an attitude, though it may suffice for the physical geographer, leads to a very narrow and ineffective conception of human geography, since it eliminates any real study of man himself. A view which is more satisfying mentally, and more fruitful in its results, is the one that admits a study of the various human groups in their regional diversities, and as influenced not only by their physical environments but also by the nature of their own adjustments to those environments. Moreover, this approach is in harmony with the dictum that the geographer's 'unit is the place or region', for do not human groups with their differing physical characteristics, their varied cultural or social backgrounds and their different economies, contribute something at least as vital to the distinctive quality of any place as do relief, rocks, soils, plants or air masses, despite the fact that the former are not necessarily shown on the ground? This is the theme of the presidential address by Prof. R. H. Kinvig to Section E (Geography).

This attitude to human geography was a feature of the teaching of Prof. P. M. Roxby, who built up such a famous Department of Geography at Liverpool, where the first Honours School of Geography in Britain was initiated in 1917. Roxby, who had a very marked historical background, in addition to first-hand experience of several regions of the world, was able to develop very effectively various ideas he obtained from Herbertson, his tutor at Oxford. Although the latter's name is linked primarily with that of natural regions, he was deeply impressed with the need for systematic studies in the human sciences—anthropology, sociology and political institutions—on which he was engaged at the time of his death; and in a paper on "Regional Environment, Heredity and Consciousness", published posthumously, he showed clearly enough the direction of his thoughts.

The data of human geography can be most conveniently divided into four categories—racial (or biological), social, economic and political—which provide a useful working scheme, although there is much overlapping between these factors. They find their fullest fruition when brought together with the

different aspects of physical geography and interrelated in a comprehensive treatment of some specific region, for example, tropical Africa, the Far East, or the local area. The evolutionary aspect of human geography constitutes historical geography, which has proved itself more and more to be an illuminating approach to the understanding of any period of history or prehistory, as well as being a prerequisite for any sound regional study.

This extension of the range of the geographer's contacts with the various social or human sciences is in keeping with developments which took place in the earlier part of this century in regard to the natural sciences. Objection was, indeed, raised in 1905 to the extension of the geographer's interest into the realm of geology and meteorology on the plea that the geographer did not "require to go beyond the purely orographical", and that he should not "intrude on geology or other sciences"; but it is quite clear that the subject would have wilted if this line had been adopted. So, too, it may be asserted that geography will only attain its full development when its growth is stimulated by both the human and the natural elements.

OPEN AND REPRESSED MONETARY INFLATION

PROF. F. W. PAISH states in his presidential address to Section F (Economics) that applied economics is more an art than a science. Its main problem consists not in discerning the relationships between given data but in choosing the data which can be regarded as significant for any given problem. Just as a dozen different artists may see a dozen different significant patterns in the same landscape, so each applied economist has to make his own personal simplification of the infinitely complex system of relationships which makes up the real world. The simplified models which he himself finds useful will therefore not suit everyone.

To Prof. Paish, inflation means, not a rise in prices, but a rise in money incomes without a corresponding rise in real incomes. Its cause is that people spend during a given period more money than they have previously received during the same period. There are two ways in which people can spend more than they have received in a given period: one is by spending money which they had in their possession at the beginning of the period; the other is by spending newly created money. Ordinary people cannot safely create money; but there are certain institutions, which can be called the banks, which do create money and lend it to persons, businesses, or the government. Such additional expenditures, whether out of previously idle balances or out of newly created money, cause inflation only when they are used for income payments; otherwise they merely raise asset prices and lower the rate of interest.

An inflation caused by the activation of idle balances may go to considerable lengths, but it cannot continue indefinitely if the quantity of money is limited. An inflation due to an increase in the quantity of money, on the other hand, can continue indefinitely. In the early stages of an inflation, money incomes are likely to rise more slowly than the quantity of money; but in its later stages, when further rises are foreseen, they rise increasingly faster, so that however much money is created the aggregate purchasing power of all the money in existence falls progressively towards zero, until eventually people refuse to accept it and its use is abandoned in favour of a new currency or even barter.

In a repressed inflation, such as existed in many countries during the Second World War, the government seeks to delay, by various devices, the rise in money incomes due to the increase in the quantity of money. Of these devices, the commonest is price-control, with or without rationing. In the early stages of price-control, while stocks are being depleted, idle money accumulates in the hands of retailers and other business men, who are unable to spend it on the replenishment of their stocks. Later, when stocks are exhausted, it accumulates in the hands of consumers who are unable to find anything worth while to spend it on. After the end of a war, therefore, there is more money in existence than is necessary to maintain the level of incomes. As controls, except perhaps in totalitarian countries, tend to break down in peace-time, the problem arises of how to prevent the excess idle balances from intensifying the inflation by creating additional incomes. In fact, except where part of the money in existence is cancelled, either by decree or by being redeemed out of the proceeds of a capital levy, the inflation has generally continued, at least until incomes have caught up with the quantity of money. If the quantity of money is allowed to increase further, the inflation may become an open one. One reason for the reluctance to limit the quantity of money and so ultimately to bring the inflation to an end is that the end of the inflation is likely to bring increased unemployment, and the world has not yet made up its mind whether it regards inflation as a greater evil than unemployment.

ENGINEERING IN THE NEXT 2,000 YEARS

THE presidential address to Section G (Engineering) by Lord Dudley Gordon looks forward to possible development in engineering during the next two thousand years, and commences by consideration of the available sources of fuel to provide power and minerals to supply raw materials out of which engineering equipment can be manufactured. Estimates as to the supply of the major fuels of coal and oil are discussed.

This leads to the consideration of the possible development of nuclear energy as a source of power and the future prospects for the supply of uranium. It is suggested that a long time may elapse before nuclear energy becomes the most important source for the production of power.

Another possible source of power is hydrogen, recoverable either from the air or from the sea, and the dangers of the release of large quantities of ordinary hydrogen are pointed out. Reference is made to Sir Charles Darwin's suggestion that there may be hopes of the successful use of heavy hydrogen as a fuel. Another source of heat which can be turned into power may be that existing in the inner part of the earth. In this case again there are obvious dangers which have to be avoided.

Sources of power which do not depend on the production of heat are water-power, which is already largely used and which will not be exhausted within any measurable period, and the energy derived from the use of ocean tides, which is again an inexhaustible supply. Wind is also an inexhaustible supply from

which the production of power is already being undertaken. Further, there is a possibility of making use of heat from the sun's rays.

Some reference is made to the idea of controlling the force of gravity in such a way that it could be used for the production of power; but admittedly this is based on pure conjecture and is not supported by any knowledge existing to-day.

The increasing speed of air travel is discussed, and suggestions are made as to how this may have to be dealt with in the future.

With regard to supplies of materials for the development of engineering, it is suggested that iron and steel will continue to be the main source for several hundred years, and that further improvements may be looked for in the composition and structure of metals so that the same results can be achieved with a much smaller weight of material.

The science and practice of engineering will certainly be called upon to help in solving the problem of supplying sufficient food for the increasing population of the world, more particularly when it is realized that with the rising standard of living the demand for food will increase at a greater rate than the increase in the population. In this connexion the supplies from the sea will become a more and more important source.

The present generation of young engineers has not merely a great opportunity, but also a great responsibility, for developing methods which will make it possible for the progress of man to continue in future centuries.

ANALYSIS AND DESCRIPTION IN SOCIAL ANTHROPOLOGY

THE title of the presidential address by Prof. M. Fortes to Section H (Anthropology) is "Analysis and Description in Social Anthropology". He points out that the ethnographic monograph of to-day is as much a study of a problem as a record of the facts of observation. This is due to the influence of the functionalist theories and methods associated with the work of B. Malinowski and A. R. Radcliffe-Brown, but already foreshadowed in some of W. H. R. Rivers's ideas. Intensive study in one society at a time is thus used as a means of testing, amending and adding to the generalizations of social anthropology, and has in fact shown itself to be more profitable than the comparative method for these purposes.

Functionalist anthropology has proved to be so fruitful in theoretical contributions because it demands an analytical, as opposed to a descriptive, mode of investigation. It is true that even the simplest descriptive statements in ethnography imply the isolation of standard and recurrent features of custom, but it is at the higher levels of analysis that the significant theoretical problems emerge.

The essence of description in anthropology is that observations are grouped in accordance with their actual relationships in time and space. Thus a descriptive account of marriage starts with the heterosexual interests of children, then goes on to initiation ceremonies, courtship, wedding rites, and such legal formalities as the payment of bride price, ending, perhaps, with some discussion of divorce. The analytical method breaks up these empirical sequences and concomitances of custom and social relationships by reference to 'ideal isolates'. These isolates are theoretical constructions, and if they are to yield valid generalizations they must fit together in a system. A good example of an analytical isolate which satisfies these requirements is Malinowski's well-known concept of reciprocity. Again, Radcliffe-Brown's discussion of the functions of kinship institutions in distinguishing, ensuring and transmitting rights over things and persons develops analytical concepts. Analytically, we think of a custom or institution as if it were made up of a number of isolates, and of an isolate as if it were an element in divers customs and institutions.

Recent studies of marriage in African societies have shown how valuable an analytical approach is. A common view, long held, is that the essential feature of African marriage is the exchange of one woman for another, if not directly then through the mediation of the bride price. This seems to fit the descriptive observations. But analysis shows that this explanation is incorrect. What is really at issue is the transfer of rights which may be held conjointly or vested separately. The two sets of rights chiefly involved are those over a woman's reproductive capacity and those over her sexual and domestic services as wife; and these rights may be held by separate persons or groups.

This is strikingly brought out in societies that reckon descent, inheritance and succession in the matrilineal line. Studies already made in West Africa and Central Africa can be cited. But a better illustration is provided by unpublished field data on Ashanti marriage. From these data it is clear that a woman's lineage never alienates her reproductive powers. At the same time, a very high regard is paid to paternity, and the moral claims flowing from fatherhood are affirmed in marriage. In marriage, only rights over the sexual and domestic services of the wife are transferred to her husband, who thus acquires a claim to the paternity of the children, but not legal control over them. Cross-cousin marriage is one device for reconciling the divergent and often conflicting claims and rights of matrilineal kin, and kin through marriage and parenthood.

Analytical methods have been most successful in the study of social organization. Further advances will be made when they are extended to the study of the more complex aspects of culture, such as religion and art.

QUALITY AND QUANTITY OF PROTEIN FOR MAN AND LIVESTOCK

THE problem of quality and quantity of protein is ever present in our daily speculations about what we shall eat and wherewithal we shall be clothed. The scale of agricultural production to meet our needs has always been a matter of concern. Quality and quantity of protein cannot yet properly be separated. This forms the subject of the presidential address by Dr. D. P. Cuthbertson to Section I (Physiology).

Although the number of proteins in our foodstuffs is very large, they are constructed out of some twenty different units—the amino-acids—the position and preponderance of which in the molecule vary with each kind of protein and give to it its peculiar properties, some of which come to light in the processing and cooking of foods, and for man frequently provide an attractive texture.

The process of digestion of proteins ultimately provides the organism with these constituent amino-acids and possibly also simpler peptides. From these 'building-stones' the organism can create or renew

the fabric of its tissues, its enzymes, hormones and other protein and non-protein–nitrogenous constituents. The evidence appears fairly conclusive that all the amino-acids that are components of a particular protein must be present simultaneously in a tissue before net synthesis will proceed smoothly. The individual proteins in the ration or diet tend to supplement each other in terms of the proper balance of nutritionally essential amino-acids. It is now known that, for man, several plant proteins and particularly mixtures of them are sometimes as efficient in supplying the essential amino-acids as some animal proteins, but that, in general, animal proteins, since they approximate more nearly to the needs of the animal and are free of cellulosic 'wrappings', are particularly well adapted to the needs of the growing child and for reproduction and convalescence. Further, associated with animal proteins are accessory factors such as the B-vitamins. We recognize that the demand for meat is not necessarily a requirement for protein. The extractives of meat stimulate appetite and provide these B-factors.

The requirements of the bird in respect to its feathering, growth of flesh and egg production are considerable and vary according to size, age and breed. From the qualitative point of view it seems that most of the amino-acids essential for growth of the chick are also essential for egg production in the adult bird. Success in compounding rations for non-ruminant livestock such as poultry and pigs is based on the optimal use of vegetable and, where necessary, animal products so as to provide the essential amino-acids in the right proportions and amounts, as well as vitamins of the B-group.

While in the ruminant micro-organisms break down protein in the paunch with liberation of ammonia, they also contribute abundantly to the supply of protein ultimately available for digestion in the abomasum and small intestine of the ruminant animal, rendering it less susceptible to critical deficiencies of individual amino-acids in its food proteins than other classes of stock and man. The degree of formation of ammonia in the rumen from the degradation of proteins may be an important factor in determining their usefulness to the animal. Processing may have effects on the value of a protein for ruminants quite different from those on the value for non-ruminants.

In the processing of foodstuffs for man, the sensitivity of amino-acids to destruction by heat must be kept continually to the forefront, and means sought to avoid their destruction; and in the case of cereals, improvers must be sought which do not damage their proteins.

Variations in the protein content of cereals through climate, fertilizer or genetic effects are probably of importance where the level of protein intake is critical, as in animal feeding.

The newer quantitative methods of estimating the amino-acids in protein based on the Moore and Stein chromatographic technique are of great value in elucidating the make-up of dietary proteins. The investigations in Belgium of Bigwood and his workers on cassava are noteworthy.

An inspection of consumption level in the United Kingdom shows that the percentage of the total calories in the diet represented by its protein moiety remains a very constant fraction irrespective of social class and level of energy expenditure. The rise in the consumption of animal protein which occurs wherever circumstances allow is particularly noteworthy when we consider that, from theoretical considerations, there is no proof that a proper mixture of plant proteins *per se* may not be as good for maintenance and even for growth and reproduction as proteins from animal sources, provided there is sufficient of it. But as we have observed, the demand for animal protein may be also a demand for its associated factors.

In animal husbandry, the farmer has learned to vary the proportions of protein and its quality in the feed according to the physiological need of the animal. In the Second World War the State assumed the role of husbandman also for its human population. In peace we like freedom, for we are less uniform than selected farm-stock.

PSYCHOLOGICAL PROBLEMS IN THE RECOGNITION OF EXCELLENCE

A COMMENT that might be made on contemporary psychology both by other scientists and by our colleagues in the humanities is that in its necessary concern with average and sub-average people it has given too little direct attention to those who are outstanding for excellence of some kind. This forms the topic of Prof. D. W. Harding's address to Section J (Psychology). It seems important to understand the conditions of excellent achievement, since general progress commonly occurs through advances made by unusual people and gradually followed up by the social group as a whole. The relation between outstanding people and the rest of us is part of the broader question of relations between people of different levels of ability or quality of mind. Waste of human resources occurs through the obstruction or neglect suffered not only by the very great but also by many people of more moderate excellence, including gifted children whose potentialities have not been discerned, and may excel those of their teachers and parents.

Two broad problems concern the psychologist: first, that of the mere perception of excellence, especially excellence surpassing one's own; secondly, that of the response to perceived excellence, whether it excites, for example, generous admiration or jealousy and attempted disparagement. A good relation between people of differing levels of ability depends on the attitude of the abler as well as that of the less able person. If the latter is to maintain his self-respect and psychological security he must feel that the other recognizes the value of his contribution, however small, to the common task; and recognizes his equality as a person, however subordinate his function may be. The ability to convey to subordinates one's recognition of their equality as persons is one mark of good leadership, and the basis of it deserves more attention from psychology. In some activities (for example, in amateur games and sports) the perception of excellence is aided by objective assessments of performance, and the response to it is so controlled by usage and convention that good relations are maintained between people of widely contrasting levels of ability. When less objective performances and more intangible qualities are in question, the difficulties of assessing oneself in comparison with others become formidable and various.

We know rather little at present, not only about the recognition of excellence in others but even about the psychological processes involved in making an advance ourselves and recognizing that our own

present standards are higher than those we once accepted. Many of the unanswered psychological questions in this field are the concern of the social and experimental psychologist; others invite the aid of the psychopathologist, for example, the effect of the child's view of his parents and the effect of sibling jealousy on his later attitudes to greatness and superior achievement in others. Any direct psychological study of the conditions governing the achievements of distinguished people, whose minds may far excel those of the psychologists who undertake it, must raise special problems of technique which have up to the present received comparatively little attention.

EVOLUTION OF THE OVULE IN PTERIDOSPERMS

PROF. JOHN WALTON discusses the "Evolution of the Ovule in Pteridosperms" in his presidential address before Section K (Botany). The dominant groups of plants of the present day, the Angiosperms and the Gymnosperms, reproduce by means of seeds, and there is no doubt that the acquisition of this method of reproduction has been largely responsible for their dominance over other groups such as the ferns and their allies, which reproduce by means of spores. There is, however, some evidence to support the view that the seed habit has evolved from the spore habit, and it is likely that clues as to how this came about may be found among the fossil remains of plants of early geological periods.

In the fern type of reproduction the spores are liberated from the plant and produce on the ground small sexual plants (gametophytes), which are delicate structures dependent on moist conditions; their survival is often a matter of chance. For fertilization to occur, water must be present so that the male gametes can swim to the ovum in the female organ. This water is provided by rain or dew. Reproduction as well is therefore somewhat chancy. In seed plants the spore which produces the female gametophyte is retained in the ovule on the parent plant and once the pollen which contains the male gametophytes enters the micropyle in a gymnospermous seed or is deposited on the stigma of a flower the future development of the gametophytes and the process of fertilization are carried out within the protective integuments and are not dependent on external climatic conditions. The embryo is protected in its development and is provided in the seed with a food supply which on germination allows the seedling to build up a root and leaf system relatively quickly. Most seeds, moreover, can remain in a dormant condition during periods unfavourable for growth.

The earliest records we possess of plants which had seeds are from the Lower Carboniferous, which was about 250 million years ago. These extinct plants, to which the name Pteridosperms has been given, had the external appearance of ferns with large compound fronds, and the seeds were borne on these fronds. Their internal anatomy, however, differed considerably from that of ferns.

The seeds of the Pteridosperms have a complicated structure. The seed itself consisted of a nucellus, the part which corresponds to the spore case or sporangium of a fern, which contained as in modern seeds a single functional spore. The apex of the nucellus in the more primitive types of Pteridosperm seeds had a tubular structure, the salpynx, which captured the wind-blown pollen, which was then drawn down it into a special pollen chamber. The nucellus was partly enclosed in a sheath, the integument. In the primitive forms the apex of the nucellus was free so that the pollen reached it directly, while in the more advanced types the integument was almost completely closed over the nucellus, leaving a very narrow pore, the micropyle, to allow the pollen to reach the nucellus. The function of capturing the pollen was therefore assumed by the integument.

The evidence, too, suggests that the ancestors of these plants had fully exposed sporangia and that the integument was evolved by a concrescence of parts of the frond which formed an enclosure around the sporangium or nucellus, the whole structure constituting the ovule or seed. In the same manner, another investment of the seed was produced, the cupule or husk, in which the seed or in some instances several seeds were enclosed. Both the integument and the cupule contained vascular tissue.

There are two major groups of Pteridosperm seeds, the Lagenostomales and the Trigonocarpales. The former seem to be more primitive in construction while the latter are more evolved and are mainly restricted to the Upper Carboniferous. The Trigonocarpales do not have a cupule, but their structure suggests that this is because the integument had become much reduced and almost completely fused with the nucellus, and the cupule then assumed the function of a second integument of the seed. The seed of the Trigonocarpales type may thus be regarded as having a double integument like many Angiosperm seeds.

These early seeds were fully exposed on the fronds, in contrast to those of living Gymnosperms and Angiosperms, whose seeds are usually enclosed in cones or ovaries. It would seem that with increasing degree of enclosure seeds became simpler in structure, the nucellus reduced to undifferentiated parenchyma and the integuments losing their vascular tissue. In the Angiosperms, where the ovules are completely enclosed in an ovary and fertilization is effected by pollen tubes, the micropyle has in some apparently no function; and it is only in some of the more primitive Angiosperm orders that there is vascular tissue in the integuments.

GREEK OR CHEMISTRY OR BOTH

THE dichotomy which exists between the education of the humanist and that of the scientist is stressed by Dr. R. Birley in his presidential address to Section L (Education).

The great scientists of the Renaissance lived in the same cultural world as that of all other well-educated men of the time. They had the same educational background; the scientist had as an audience the whole of educated society. This unity has been lost, and in our culture there is a deep rift between the humanist and the scientist. The two have different educational backgrounds. The executive Civil Servant, who will almost certainly have had a humanist education, cannot understand the attitude of the scientist; the scientist has not been prepared by his education to accept the responsibilities which the power of science gives. Hence there is a feeling of helplessness in our society. Men who have social responsibilities feel helpless before a power which they cannot control or understand; men who control that power feel that they cannot concern themselves

with the social responsibilities in which it involves them.

The existence of this dichotomy is widely recognized, and some attempts are being made to solve it at the universities by the introduction of general studies. Such attempts, however, do little more than paper over the cracks. The only way in which education can help to solve it is by ensuring that the two classes actually work together. This is impossible at the universities, and not much can be done in the sixth forms of the grammar schools, for in them children must spend most of their time on specialist work preparatory for the university. Moreover, by the time a boy or girl enters the sixth form he needs such specialist work for his full intellectual development.

The solution lies before this stage. The ablest children below the sixth form should work together at all subjects, except, perhaps, mathematics. They should study together the same humanist subjects, whether or not these include Greek, and take the same course in science. The abandonment of the 'half-specialization', now common below the sixth form, would inevitably entail some lowering of standards in the sixth form, and presumably in university entrance requirements, though by the time the educational process was finished it is doubtful whether the standards would be lower. All the ablest citizens in the country would then have had a common educational experience.

In the sixth form some periods should be set aside when boys and girls specializing in the various studies should again work together, at the humane subjects or science. This work would differ from ordinary specialist work, though the fact that all had learnt the grammar of the subjects should prevent it from being merely superficial. The scientist, when science was being studied, would do much to educate the specialist in a humane study, and, *mutatis mutandis*, the classic or historian would help the scientist.

It would not be easy to fit such a scheme within the framework of the national system of external examinations, which, just because they are devised to fit in with the requirements of the schools, make experiments by individual schools difficult. A far greater obstacle would lie in the most serious shortage of able science teachers in the grammar schools. This is now so acute that it is futile any longer to talk of the development of the scientific strength of the country or to plan institutes of technology or other similar institutions until it is remedied. Unless a solution is found to this problem, the universities will before long find that they have to teach elementary science.

APPLICATIONS OF 'ANIMAL PHYSIOLOGY' TO AGRICULTURE

THE theme of the presidential address by Dr. John Hammond to Section M (Agriculture) is that 'animal physiology' as a basal science for animal production has to co-ordinate the results of pure scientific research in anatomy, zoology, genetics, physiology, endocrinology and biochemistry, and to determine the interactions between these, so that control over animal production can be obtained. In doing this it is often found that large gaps in knowledge exist between the various pure sciences—for example, methods of control over the shape and composition of the animal—and these have to be filled in. While present-day medical and veterinary physiology can provide many techniques, they are too narrow in outlook and deal too much with critical short-time happenings in the body and too little with the chronic long-term results which are necessary in animal production. 'Animal physiology' is therefore supplementary to medical and veterinary physiology although it interlocks with them.

The rate and efficiency of the process of reproduction form the basis of economic animal production. At present the fertility of our farm animals is much below its potential level. The number of fertilized eggs which can now be obtained by injections of gonadotrophic hormones far exceeds the capability of the dam to mature them to birth, so that experiments are now in progress to find out whether eggs of good genetic worth may be transplanted to and incubated by dams of inferior genetic qualities. Such methods would also be useful for the cheap aerial transport of the larger domestic animals and for producing pure beef calves from dairy cows. Such things are now possible in the rabbit, and their application to cattle awaits development. The control of anterior pituitary gonadotrophin action by changes in the daylight–darkness ratio offers a method of regulating the breeding seasons in sheep and horses, which in the case of the former can now also be done by hormone injections. The application of the technique of artificial insemination to the mass improvement of dairy cattle, and to the production of beef cattle from dairy herds by the use of 'colour-marked' bulls, has already been extensively used in practice. The new deep-freeze method whereby bull semen can be kept fertile for at least a year offers possibilities for the pedigree breeder and for world distribution at cheap rates.

In milk production, studies of the mechanism of the 'let-down' of milk have resulted in better milking practices and machines. Sterile heifers can be brought into milk by the application of synthetic œstrogens, and good yields obtained in many cases. The effect of the plane of nutrition of the animal on the quantitative results obtained from hormone action, as shown by the 'steaming up' of dairy cows and the 'flushing' of sheep, is of great importance for economic production.

The development of early maturity and meat qualities in livestock depends on our being able to control growth and the relative proportions of the different parts of the body. Physiological and anatomical age can be advanced on chronological age by high-plane nutrition and retarded by low-plane nutrition. The maternal influences of uterine nutrition and lactation have a great influence on the development of early maturity in meat animals. The finding that the partition of incoming nutrients between the different tissues and parts of the body depends on the plane of nutrition is of importance not only for the economy of meat production, but also for methods of genetic selection.

The physiology of body-temperature regulation has important practical applications both for economic production and for survival under low air temperatures with pigs and under high air temperatures with cattle. The study of animal behaviour promises to create a science of the 'stockman's art'.

There is need for extension of the study of methods of control over animal functions if we are to develop an intensive animal production in Great Britain, for we must either do this or be content with a lower standard of living.

GATEWAYS OF SCIENCE

In his presidential address to Section X (Assembly of Corresponding Societies), Dr. W. E. Swinton directs attention to the history and function of the new Assembly as descendant of the Conference of Delegates and contrasts them with those of other sections and the Association as a whole. He regards the meeting of the whole Association as the remnant of what was once tantamount to the annual meeting of the shareholders interested in national, if not nationalized, science—the remnant, because only a small part of the sectional business is nowadays within the comprehension of the general public, which is numerously represented in the annual meeting. In the circumstances, he feels that the Assembly has the duty of catering for many of these interested laymen and of reaching out beyond the annual meeting to the great masses of people who have a right to know about scientific plans and progress.

This is the more essential since it is becoming widely realized that the starting and maintenance of a scientific process or programme is only the beginning of a chain of events that might have great political and ethical results as well as intellectual by-products. Prof. A. V. Hill, at Belfast, directed attention to the dilemmas of science, to the need for orientation and re-orientation of its progress, and the members of the general public have a right to know, as beneficiaries or as victims, where they are likely to stand in the composite picture. There are also the many who follow science, as Sir Edward Appleton has shown, for its own sake.

The Assembly is the inheritor of a rich history of collaboration with the societies which, year after year, fight a battle, sometimes a losing one, for better public understanding of science, especially archæology and natural history. Many of these societies are old; it might be thought that the fight is no longer serious, that generally the recognition of so-called scientific truths is assured. Yet it is not so in many highways and byways; one does not have to work long in a museum or to give many broadcast talks to realize that the truths themselves are challenged, that the "Origin of Species" which sought to emphasize the rise of man is frequently interpreted as a sign of his fall. The biological study of man, it might be contended, has lowered his stature. Although the publication of Darwin's great work was an intellectual milestone, executions in England were still carried out in public for ten years after its first appearance; but there are many other better known social and medical facts which support the contention that the increase of biological knowledge has gone hand in hand with an increase in man's prestige.

To satisfy adequately the just demands of the general public calls for a rearrangement of the Assembly's outlook. There must be an increase in facilities for both the young and the not so young to have the best advice in scientific career fact-finding. Here the rich stores of experience in the Association should be tapped. There must also be increased facilities for the flow of authoritative information to the general public, individually or in groups of adult students.

The existing facilities in science for adults include: the libraries, museums, societies, the Workers' Educational Association, the B.B.C., and other bodies. It is clear from a conservative study of the figures available that there are thousands of persons almost habitually unable to attend the British Association meetings who are none the less well within the range that the Association desires to serve. In these circumstances a new form of membership—a corresponding membership—should be considered. This could be arranged so that aspirants to professional education and entry to the scientific services can have the advice they need. On the other hand, he outlines the kinds of services, reading lists and guidance in studies in and out of doors that could be given to adults and study groups. None of this need conflict with existing services but could be collated with and amplify them, and more immediately govern their trends.

Such a programme is important and will become increasingly so. It is important to consider the matter on a high level, and Dr. Swinton suggests a surveying committee to review and prescribe methods of co-operation between the British Association, Library Association, the Museums Association, the Unions of Scientific Societies, the Workers' Educational Association, the Further Education Section of the B.B.C. and representatives of the education authorities.

This would at least ensure the continuance of the great interest in the British Association's work and ideals which adults and the young, the regional and local education authorities, and many other responsible bodies have so abundantly demonstrated in Belfast and Liverpool. With it the gateways of science should be more freely opened.

OBITUARIES

Dr. M. H. Gordon, C.M.G., C.B.E., F.R.S.

With the death of Dr. M. H. Gordon, on July 26, aged eighty-one, British bacteriology has lost one of its outstanding figures, while the world mourns the passing of one who did good to all men. His work, much of which was that of a pioneer, has been deeply appreciated in his own country, and indeed throughout the world, by his professional brethren; but it is not primarily as an exponent of his profession that Gordon will be remembered by those who had the good fortune to be his friends—he will live in their memory because of his personal qualities, his geniality, his enthusiasm, his understanding and, in a very special way, for the kindness he showed to junior colleagues, many of whom owe to him a real debt of gratitude because of the encouragement given to them by him in their formative years. Widely read in many subjects far remote from his chosen speciality—literature, the fine arts and, above all, history—Gordon's companionship was both stimulating and satisfying. He inherited from his Scottish ancestors a liking for controversy, and an evening spent with him, enlivened by argument often acute but never bitter, was an unalloyed pleasure: he was one of those rare souls with whom one could agree to disagree and remain a firm friend.

Gordon's active life as bacteriologist and immunologist covered almost a half-century in which profound

changes in outlook occurred and dramatic advances were made in the fields of preventive medicine and therapeutics. His early work was performed at a time when the technical armamentarium of bacteriologists was restricted; but he used the simplest procedures with ingenuity and with a consummate artistry which was delightful to see: indeed, he recalled what Max Gottlieb in "Martin Arrowsmith" regarded as the ideal research worker—one who fabricated his apparatus from a packet of tooth-picks.

Gordon's early investigations included the study of water-borne enteric fever, and in this, along with the late Surgeon-Colonel Reece, he carried out some of the earliest work on chlorination of water supplies. His study of the *Streptococcus* led him to believe that that micro-organism was the causal agent of scarlet fever and, although he failed to prove the validity of his views, his work made possible those later investigations upon which it is now accepted that that malady is due to infection with *Streptococci*. This work assisted greatly those who in later years defined clearly the mechanism of the pathology of scarlet fever and elaborated means for preventing that illness. As a bacteriologist, perhaps the most fruitful period of his life was during the First World War, when he was called upon to deal with cerebro-spinal fever in the Armed Forces. The work which he performed, along with the team he so ably led, did much to elucidate the epidemiology, the bacteriological and the immunological problems of that malady which has proved a scourge to armies throughout history. The account of these investigations, embodied in a report to the Medical Research Council (Special Report Series No. 50; 1920), remains a classic.

In his later years Gordon devoted his attention to the study of virus diseases, notably the 'pock' infections, and he elaborated a procedure for the diagnosis of smallpox which, prior to the introduction of culture on the chorio-allantoic membrane of the developing chick, was the only accurate and delicate method whereby a diagnosis of modified smallpox or of smallpox minor could be made quickly. The Gordon flocculation test for the diagnosis of smallpox was used successfully to control more than one outbreak of smallpox minor, which presents problems of peculiar difficulty to the public health service. He played an important part in co-ordinating the work of those who contributed to the Rose research on lymphadenoma, and his interest in lymphadenoma was maintained throughout the remaining years of his life.

For many years Gordon was a member of the Advisory Committee on Pathology to the War Office, and for his services to his country he was rewarded by the conferment of the C.M.G. and C.B.E., while his contributions to the advance of knowledge earned for him the fellowship of the Royal Society and, perhaps what gave him most pleasure of all, an honorary LL.D. from the University of Edinburgh. A trait in his character which endeared him to all was that he accepted these honours as an appreciation not only of his own worth but as a recognition of the help he received, and which was given so willingly, by his collaborators.

W. J. TULLOCH

Dr. Willoughby Gardner

DR. WILLOUGHBY GARDNER, who died on June 29 in his ninety-fourth year, was of Lancashire stock and the elder son of the late Henry Gardner, of Birkenhead, and of Caroline Huffam Gardner, *née* Willoughby. Educated at Rugby, he went into his father's business at Liverpool but retired as a comparatively young man for health reasons, and settled at Deganwy; there his numerous activities made him for many years a notable figure in the cultural life of Wales. He developed an area of land there as a unique building estate, under regulations which provided that the purchaser of each plot (already planted with trees and flowering shrubs) should build a house of character in keeping with the surroundings.

His early enthusiasm for fishing led him to the study of entomology; as far back as 1901 he published a list of the Hymenoptera Aculeata of Lancashire and Cheshire, and this group was his special interest. His collection of British Aculeate Hymenoptera, including material from North Wales, was presented by him about two years ago to the Zoology Department of the National Museum of Wales. He was a Fellow of the Linnæan and the Royal Entomological Societies, and also of the Society of Antiquaries. His presidential address in 1928 to the Lancashire and Cheshire Entomological Society, dealing with the sixteenth-century entomologist Thomas Penny, shows a happy combination of his zoological and antiquarian interests, and was the result of much research.

A keen archæologist, Dr. Gardner was long a leading member of the Cambrian Archæological Association and of its various committees, and president in 1926. In his presidential address, published in *Archæologia Cambrensis* of that year, he summed up the results of his work on the significance and history of the great hill-forts of North Wales, many of which he had personally surveyed and planned, besides excavating those of Y Corddyn and Dinorben in Denbighshire. He was also a prime mover in organizing the excavation of the Roman sites of Segontium at Cærnarvon (by Sir Mortimer Wheeler) and of Kanovium at Cærhun on the River Conway (by Mr. Baillie-Reynolds). He was an original member of the Ancient Monuments Advisory Board for Wales, and of the Wales Advisory Committee of the National Trust and of the Board of Celtic Studies of the University of Wales. In recognition of his work in this sphere the University of Wales conferred on him in 1927 the honorary degree of doctor of science.

His interest in numismatics (he was a Fellow of both the British and the Royal Numismatic Societies) led to the formation, during nearly seventy years of his life, of a fine collection of Anglo-Saxon coins of the Chester Mint, which is now in the Grosvenor Museum at Chester.

One remembers Gardner as a man of wide interests, of great energy in pursuing them, and of "a nature sloping to the southern side".

COLIN MATHESON

WE regret to announce the following deaths:

Mr. W. A. Dillon-Weston, chief plant pathologist for the eastern province of the National Agricultural Advisory Service, on August 20, aged fifty-four.

Prof. C. Leonard Huskins, professor of botany in the University of Wisconsin, aged fifty-five.

Prof. L. Prandtl, For.Mem.R.S., of the University of Göttingen, aged seventy-eight.

Mr. T. Raymont, formerly principal of the Goldsmiths' College, University of London, on August 13, aged eighty-eight.

NEWS and VIEWS

Radar-Sonde Meteorological Station at Crawley

Mullard, Ltd., have given details of the *radar-sonde* system which they have developed in conjunction with the Telecommunications Research Establishment, Malvern, and which they are at present installing for the Meteorological Office in a specially built station near Crawley. The system is designed to measure winds up to heights of 100,000 ft. to an accuracy of 3 knots, and with the addition of some extra components it can also be used to measure pressure, temperature and humidity in the upper atmosphere. Pulses from the ground transmitter on a frequency of 152·5 Mc./s. are received by the airborne unit which is carried aloft by a free balloon. The pulses are re-transmitted to the ground on a frequency of 2,850 Mc./s. and are received by an automatic following aerial. The delay between transmitted and received pulses gives the range of the balloon; this is fed into a computor together with azimuth and elevation angles obtained from the inclination of the aerial system. Wind-speed and direction are computed and recorded from the rates of change of these parameters. When pressure, temperature and humidity are required in addition to the wind, a second pulse is transmitted by the airborne unit at a time interval after the first pulse depending on the value of the meteorological variable. A switch driven by an electric motor connects the pressure-, temperature- and humidity-sensitive elements to the *sonde* in turn. The system is capable of recording the meteorological information to an accuracy of one part in 1,000. This new equipment should provide weather information at greater heights and to a much higher degree of accuracy than obtained from the present *radio-sonde* and radar wind-finding system, particularly in conditions of high wind when the existing wind-finding equipment goes out of range of the ground station at comparatively low levels.

Australian National University: University House

The Council of the Australian National University has appointed seven Fellows who, with a Master and an eighth Fellow yet to be appointed, will constitute the governing body of University House, the residential College which is nearing completion and will be opened for the coming academic year. Pending the appointment of a Master, Dr. W. E. H. Stanner, reader in comparative social institutions, will act as chairman and convenor. The Fellows already appointed are: Prof. P. A. P. Moran, professor of statistics (who will act as bursar); Prof. J. C. Eccles, professor of physiology; Prof. P. H. Partridge, professor of social philosophy; Prof. R. v. d. R. Woolley, professor of astronomy; Dr. Germaine Anne Joplin, Research Fellow in geophysics; Dr. S. Fazekas de St. Groth, senior Research Fellow in microbiology. University House, an imposing and beautifully appointed building, was designed by Prof. Brian B. Lewis, professor of architecture in the University of Melbourne. It will be the centre of the University's social and cultural life and will serve the ordinary collegiate purposes. It will be able to accommodate about 120 postgraduate students and members of the University staff.

Activities of International Scientific Unions

The *Quarterly Bulletin* for May–June 1953 of the International Council of Scientific Unions reports briefly on the first meeting of the Executive Committee of the International Mathematical Union on February 13–14; it was arranged that the next International Congress of Mathematics will meet in Amsterdam during September 2–9, 1954, immediately following the Second General Assembly of the Union at The Hague, August 31–September 1. The preferred subjects for the symposia at the Congress are asymptotic expansions, non-associative, non-linear algebras, and stochastic processes. The Teaching Commission of the Union, which met in Geneva in October, selected for investigation the role of the contemporary mathematician and comparative studies of text-books in different countries, and has established close co-operation with the Section for the Teaching and Dissemination of Science of the Natural Sciences Division in the Secretariat of the United Nations Educational, Scientific and Cultural Organization. The Commission on Abstracting and Reviewing reported that no collaboration could be arranged between *Mathematical Reviews* in America and Julius Springer of Heidelberg, publishers of the *Mathematisches Zentralblatt*. An informal meeting of the interim Council of the International Union of Biochemistry recommended holding the first General Assembly of the Union early in 1955, before the next International Congress, scheduled for September 1955. At a meeting of the Executive Committee of the International Union of Geodesy and Geophysics in Paris in April, a special committee of the Union was appointed to co-operate with the International Council of Scientific Unions Committee for the International Geophysical Year. At a meeting in Madrid in April, the Executive Committee of the International Union of Pure and Applied Chemistry recommended that the Joint Commission on Physico-Chemical Constants and Data should become a Commission of the Union, but that the Joint Commission of Radioactivity should become a Commission of the International Union of Pure and Applied Physics.

Unesco Science Co-operation Office for Latin America: Report for 1952

A report of activities during 1952 issued by the Science Co-operation Office for Latin America, Montevideo, of the United Nations Educational, Scientific and Cultural Organization (pp. 17; 1953) records the arranging of a symposium on new research techniques in physics, held in Rio de Janeiro and São Paulo, Brazil, during July 14–29, 1952, to which sixty original papers were contributed, and another on neurone and synapse, at Montevideo during October 6–12, 1952, to which thirty original papers were contributed. A meeting of experts on August 1–2 on the establishment of international and regional laboratories in Latin America recommended that the highest priority should be given to the creation of a network of international laboratories of marine biology, and that regional 'service-laboratories' for organic elementary analysis, conservation of microbiological type cultures, X-ray analysis and scientific films should be organized from certain laboratories now operating on a limited national scale. The creation of an Inter-American Institute for Cosmic Ray Research was also recommended. Three series of lectures by visiting men of science were arranged during the year, dealing with the theory of distributions (Prof. L. Schwartz), cardiac glucosides of rapid action (Prof. R. Mendez) and the clinical biochemistry of pregnanediol of urine (Prof. L. Corona). The Office now possesses a considerable

collection of scientific films and is building up a film library from which scientific films are circulated in the Region. The Unesco travelling exhibition on physics and astronomy was shown by the Office in seven cities and aroused great interest. Microfilms amounting to 5,500 pages of text were supplied during the year to institutions and individual research workers, and seventy-five bibliographies were duplicated and distributed. The first catalogue of type cultures cultivated in Latin American laboratories was published in 1952 and included entries for thirteen hundred strains. Commencing in April 1952, the first four numbers of a bi-monthly *Bulletin* of the Centre were published, and the report includes details of the co-operation of the Office in technical assistance projects in Mexico, Bolivia and Montevideo.

Falkland Islands Dependencies Survey

THE Falkland Islands Dependencies Survey has begun a series of scientific reports, of which five have been published, the first being on "Organization and Methods" (pp. 12+3 plates; London: H.M.S.O., 1953; 4*s*. 6*d*. net) and the other four on various specialized topics. The Survey, which is under the direct control of the Governor of the Falkland Islands, has its scientific bureau at Queen Anne's Chambers, London, S.W.1, where all reports and photographs are deposited. The work is mainly a land organization and is concerned principally with survey; meteorology and hydrography will find other more suitable places of publication, and some of the biology will appear in "Discovery Reports" or in appropriate journals. The major task of the Survey is the topographical mapping of the Dependencies, and a series of 1 : 500,000 maps is now being revised; the first edition appeared during 1948–49, and larger-scale maps, 1 : 200,000 and 1 : 100,000, are also being produced for scientific work. Survey parties are attached to most of the bases, so that shorter or longer sledge-journeys will eventually cover the whole of Graham Land and adjacent islands and lands. After using various chartered ships, the Survey now has its own ship, the *John Biscoe*, a wooden ship of 870 tons with diesel-electric engines; she was formerly a net layer and has proved her capability in heavy pack ice.

Rugby School Natural History Society

A SCHOOLBOY at Rugby, J. B. Booker, has recently made a valuable series of observations into the breeding of swifts (*Apus apus apus*), which has been described in the Report of the School's Natural History Society (Report of the Rugby School Natural History Society for the Year 1952. Eighty-Sixth Issue. Pp. 29+1 plate. Rugby: George Over, Ltd., 1953). A similar study had been made in 1947 and Booker's investigations were designed to supplement this; in his case almost daily observations were made of six nests. The investigation was not started until after the eggs had hatched and no information was obtained about the earlier stages of breeding. Later it was seen that the daily increase in weight of maturing birds had a definite peak and also varied according to the weather. For example, most birds would lose weight after a day of bad weather when there would be little food available in the air. The weighing procedure was as follows: the young bird was carefully eased out of the nest and put in a paper bag of known weight; the bag was then hooked on to a spring-balance, and the weight of the bird found; the bird was then put on an improvised table and de-loused and returned to the nest. At first the young birds were frightened by the light from the torch and on being handled; most of them became used to the routine after about a week. Experiments were also carried out by introducing nestlings into nests other than their own. In one or two cases the introduced nestlings were ejected from the nest. Booker also tested the popular theory that swifts cannot 'take off' from the ground. Three parent birds were captured either on the nest or resting elsewhere, placed on the road and released. One bird hopped weakly and another hit its wings on the road for the first five or six beats. They then flew at an angle of about five degrees to the road for about fifteen yards, turned sharply to one side to gain speed, and commenced a zig-zag flight and rapidly gained in height. The Report also contains an article by R. C. Paul on double stars as well as the usual accounts of the proceedings of the different sections of Rugby School's Natural History Society.

Preservation of Museum Objects

THE second issue of *Conservation* (**1**, No. 2; June 1953), the journal of the recently founded International Institute for the Conservation of Museum Objects, includes several articles of interest and use to museum curators. Dr. A. A. Moss discusses the nature of niello and concludes that it is a black sulphide or mixture of sulphides. He also maintains that the technique of inlaying with niello changed about the eleventh century. Dr. H. J. Plenderleith and Mr. R. M. Organ deal with the decay and conservation of museum objects of tin. Tne first type of decay is a local chemical one in the form of disfiguring excrescences of oxide usually of a spotty nature and hard to the touch. The second type is the so-called 'tin pest' superficially rather similar in appearance, save that the spots are soft and powdery and tend to spread and in time to puncture the metal. These two types of decay arise from different causes, the first by chemical or electrochemical action in the ground, and the second, which is more serious, by protracted exposure to conditions of extreme cold, which causes a change of crystal structure. For the conservator, correct diagnosis is important, because, whereas oxidized metal is generally amenable to laboratory treatment, an object that has suffered the allotropic change to grey powder cannot be reconstituted. Other articles included in the journal concern the impregnation and lining of paintings on a hot table, and another on the joining of the loose members of panel paintings.

College of Commerce, Bangalore

ABOUT ten years ago, the University of Mysore established a College of Commerce at Bangalore, which now accommodates some eight hundred students and provides a degree course. A new building is under construction, to be known as the Ramnarayan Chellaram College of Commerce, and the foundation stone was laid by the Chief Minister of the Government of Mysore on August 1, 1952. The Ramnarayan Chellaram and Sons Charitable Trust has now issued an appeal for gifts of books to be presented to the College on the occasion of the opening of the new building; the appeal mentions especially biographies of industrialists and scientists and literature on the origin of industries and on the humanities. Communications should be sent to the Trust, Post Box 34, Bangalore 2, South India.

Conference in London on Applied Mass Spectrometry

A conference on applied mass spectrometry, organized by the Mass Spectrometry Panel of the Hydrocarbon Research Group of the Institute of Petroleum, will be held during October 29–30 at the Institution of Electrical Engineers, Savoy Place, London, W.C.2. The main object of the conference is to bring together American, British and European workers in the field of applied mass spectrometry so as to discuss problems of current and future interest. The majority of papers are designed to interest those who use mass spectrometers in their daily work; but all the papers on the first day will be devoted to subjects in analytical chemistry where mass spectrometry has proved particularly valuable, and it is hoped that these papers will give rise to discussions of the relative merits of mass spectrometry and other methods. There will be eighteen papers in all, submitted by workers in Canada, France, Germany, Great Britain, Holland and the United States, and these will cover three fields as follow: quantitative analysis of gases, liquids and solids, including the continuous monitoring and control of product composition by mass spectrometry; applications to the study of molecular structure, free radicals, and electron-molecule collision processes; and recent developments in instrumentation and computing techniques. The fee for the conference is two guineas. Registration forms and further information can be obtained from W. J. Brown, c/o Metropolitan-Vickers Electrical Co., Ltd., Trafford Park, Manchester 17.

National Weed Control Conference

A National Weed Control Conference will be held during November 3–5 at the St. George's and Norfolk Hotels, Cliftonville, Margate, under the presidency of Sir James Scott Watson, chief scientific and agricultural adviser to the Ministry of Agriculture and Fisheries. The Conference is being organized by a committee representing the Ministry of Agriculture and Fisheries, the Agricultural Research Council, the National Farmers' Union, the British Agricultural Contractors Association (representing spraying contractors) and the Association of British Insecticide Manufacturers (representing herbicide manufacturers). The aim of the Conference is to promote an interchange of views between those engaged in research and advisory work, on one hand, and farmers and others concerned with the subject, on the other, and special emphasis will be laid on chemical means of control in agricultural and horticultural crops. The formal papers will cover the following topics: the cost of weeds and potential value of herbicides (Dr. E. Holmes, Dr. F. R. Tubbs, Dr. J. Philp and Mr. M. V. Laurie); herbicides and grassland management (Dr. William Davies and Mr. G. Maxwell Davies); machinery and application problems (Dr. H. G. H. Kearns, Mr. Cameron Gifford and Dr. W. E. Ripper); weed seeds (Mr. F. R. Horne); weed control in farm ditches and on highways (Mr. C. V. Dadd and Mr. E. C. Boyce). In addition, reports will be presented by research workers from a number of stations on weed control in cereals, grassland, sugar beet, lucerne and forest nurseries and on wild oats, crop-desiccating agents and a new herbicide. The Conference will be residential, and the fee is £8 15*s.*, including a copy of the proceedings. Provisional programmes and application forms may be obtained from the Conference Treasurer, Mr. W. A. Williams, Association of British Insecticide Manufacturers, 166 Piccadilly, London, W.1.

British Celanese Ltd. Research Studentships

British Celanese Ltd. announces the award of research studentships in chemistry, tenable for two years from October 1 at the institutions mentioned, as follow: Mr. V. A. Atkinson (Imperial College of Science and Technology, University of London), Mr. C. A. Baker (Merton College, University of Oxford), Mr. J. C. Maynard (University College, University of London) and Mr. W. Whyte Kerr (University of Glasgow).

Announcements

H.M. the Queen has appointed Prof. T. M. Knox, professor of moral philosophy in the University of St. Andrews and chairman of the University Court, to be principal of the University of St. Andrews.

The seventh Charles Chree Medal and Prize of the Physical Society will be presented to Prof. J. Bartels, of the University of Göttingen, in recognition of his valuable work in the field of geomagnetism, at a meeting of the Society to be held in the Science Museum, London, on October 23. Prof. Bartels will deliver a lecture on "Chree's Influence on Present-day Geophysics".

Dr. A. Glucksman, of the Strangeways Research Laboratory, Cambridge, will deliver the third Douglas Lea Memorial Lecture at a meeting of the Hospital Physicists' Association at 8.15 p.m. on September 25 at the Hammersmith Hospital, Ducane Road, London, W.12. He will speak on "Radiosensitivity at Different Levels of Biological Complexity".

Mr. J. Savage, deputy head of the Physics Department of the British Iron and Steel Research Association, has been appointed head of the Department in succession to Mr. M. W. Thring, who is going to the University of Sheffield as professor of fuel technology (see *Nature*, May 9, p. 820). Mr. Savage has been closely associated with the Association's work on continuous casting since 1947. He was educated at the University of Nottingham, and for a time was in charge of spectrographic research at the Royal Aircraft Establishment, Farnborough.

Two useful booklets have been compiled by the Royal Institute of International Affairs (London and New York). One is a new revised edition of "World Production of Raw Materials" (Information Papers No. 18; pp. 104; 1953; 7*s.* 6*d.* net); in this publication, after some preliminary tables on raw materials, their geographical distribution, and trends in production and uses, there follow tables of statistics giving the output for the most important producing countries in pre- and post-war years, so far as these figures are available. The other booklet is entitled "Springs of Canadian Power", and is also a Chatham House Information Paper (pp. 59; 1953; 3*s.* 6*d.* net); it gives an objective picture of Canada's place in the industrial world, with a particularly useful section on the St. Lawrence seaway, and there are several sketch maps.

Errata. "Phagotrophy in *Oxyrrhis marina* Dujardin", by M. R. Droop (*Nature*, August 8, p. 250): paragraph 3, line 5, for "with particulate nutrients" read "without particulate nutrients".

"*Bact. coli* as a Food Supplement" (*Nature*, August 22, p. 351): the author's name should be "R. S. Roberts" and not "L. P. Roberts" as printed.

RECENT DEVELOPMENTS IN ULTRASONICS AND OPTICS

SUMMER PROVINCIAL MEETING OF THE PHYSICAL SOCIETY

THE summer provincial meeting of the Physical Society, under the chairmanship of the president of the Society, Prof. R. Whiddington, was held this year in the Physics Department of King's College (University of Durham), Newcastle upon Tyne, during July 13–14. The meeting was devoted mainly to the reading of papers in the fields of optics and ultrasonics, and on the morning of July 13 four papers on ultrasonic subjects were read.

Prof. A. van Itterbeek described two studies in the field of ultrasonics performed in the Low Temperature Laboratories of the University of Louvain: the use of measurements of the velocity of sound in a mixture of fluids to determine local concentrations and hence the coefficient of diffusion; and measurements of the velocity of sound in liquid helium I. In the latter case, previous measurements had all been made at one ultrasonic frequency, but, by using several sources, a dispersion of the velocity of sound in the neighbourhood of the λ-point has been substantiated.

The second paper, by Dr. L. E. Lawley, gave an account of some ultrasonic absorption measurements made in carbon dioxide contained in narrow tubes. The tubes were of the order of 1 mm. diameter, and the viscous drag at the walls was such as to produce an absorption of the same magnitude as the peak of the carbon dioxide relaxation absorption. The measurements showed that, over a considerable range of frequency/pressure on either side of the relaxation peak of carbon dioxide, the absorption was given by the sum of the Helmholtz–Kirchhoff tube absorption and the thermal relaxation absorption of the gas.

Mr. A. W. Pryor then presented absorption measurements in several solutions and dispersions. Measurements by means of a pulse method in the range 5–25 Mc./s. were correlated with measurements taken by means of a reverberation method by Mr. R. D. C. Reed in the range of 500 kc./s.–1 Mc./s. Relaxation curves for 1·5 per cent bentonite, 1 per cent gum tragacanth and several gum arabic solutions were presented. Viscous solutions of rubber in benzene and of 'Perspex' in pyridine showed an absorption less than that of the pure solvents. For solutions of cane sugar and glucose, for concentrations up to 70 per cent by weight and at temperatures 15–80° C., the ratio of the experimental to the classical absorption is little different from that for pure water.

Following this paper, Dr. R. Roscoe gave a theoretical discussion of Mr. Pryor's results for the absorption of sound in sugar solutions. It was suggested that a considerable part of the absorption in concentrated solutions results from a high loss of energy in the neighbourhood of the mean-points of adjacent molecules. Here the water molecules are extruded when the solution is compressed, and high stresses of a viscous character are consequently introduced. When this effect is taken into account, it is found by calculation that the ratio of actual to classical absorption should be much the same as for pure water, in agreement with Pryor's results. If similar considerations are applied to pure 'associated' liquids, regarded as mixtures of solid and liquid states, a value of 2·25 is obtained for the ratio of actual to classical absorption, while the observed values for alcohols and water range from 1·83 to 3·10.

The morning session of July 14 opened with a paper by Dr. G. W. Series, who described the work carried out at the Clarendon Laboratory, Oxford, on the Lamb shift in hydrogen-like spectra. It is now well established that the energy-levels of atomic hydrogen and ionized helium are not in the positions predicted by Dirac's theory. The shifts of the $2S$ and $3S$ levels in deuterium have been studied by measuring the components of Hα. The line width in the source was reduced by liquid hydrogen cooling, and two Fabry–Perot étalons in series resolved the structure. Details of this work have been published[1]. The structure of the He^+ line 4686 A. has now been studied in a similar manner. The doublet $3S_{1/2}$–$4P_{3/2}$, $3P_{1/2}$–$4D_{3/2}$ and nearly all the other components have been resolved, and it is concluded that the only levels which are appreciably displaced are $3S$ and $4S$. Provisional values are 0·139 cm.$^{-1}$ and 0·054 cm.$^{-1}$, respectively. Some weak components are affected by overlapping lines due to traces of molecular hydrogen, and work to overcome this difficulty is still in progress.

Dr. T. A. Littlefield described how ghosts had been found with the two reflecting échelons in use at King's College, Newcastle. The Foucault knife-edge test, used in conjunction with a mercury-198 lamp, showed clearly why ghosts were much more prominent in one than the other, which in use had proved acceptable. Since the knife-edge test was being applied to an interference fringe, a simple calculation determined the contour of the échelon surface. The possibility of figuring the échelon surface was considered; but preliminary attempts have so far been unsuccessful owing to the method of construction. The back surface of the échelon may also be used. The knife-edge test showed that this is as good as the acceptable échelon, and photographic tests of the figures have confirmed this.

Dr. E. E. Schneider began his paper on "Microwave Spectroscopy of Solids" by describing paramagnetic resonance experiments with zinc sulphide–manganese phosphors (down to a millionth part of manganese). Results on line widths and on the dependence of the resonance pattern on crystal structure were presented, particularly on a small scarcely resolved fine structure in cubic phosphors. Dr. Schneider then turned to results obtained with single crystals of sodium chloride containing manganese (0·01 per cent). Prior to heat treatment, only broad resonances are observed, indicating an aggregation of manganese ions. Moderate heating and quenching lead to a complex resonance pattern exhibiting both hyperfine structure and a strongly orientation-dependent fine structure which suggests that manganese ions liberated into the lattice are accompanied by cation vacancies. The paper was concluded by a brief account of microwave resonance experiments with coloured alkali halides.

The conversion of a Unicam *S.P.*500 photometer to an optical null-type of double-beam spectrophotometer was described by Mr. R. V. Hesketh. It was indicated that the accuracy of the instrument depends on the sensitivity of the null detector and the accuracy of the attenuator in the comparison beam. The null detector is a low-frequency oscillator of special design and forms a phase-sensitive detector of high

sensitivity. Modulation of the light beams is produced by a mechanically resonant system requiring little power. The optical system employs a minimum of mirrors and is asymmetrical. The asymmetry is used to advantage in the design of the attenuator. This has a linear calibration throughout the transmission range. Errors due to the inhomogeneous intensity of the light beam are eliminated by the design. The performance of the instrument is such that a change of 0·005 in an optical density of 2 may be detected using a light intensity of 10^9 quanta/sec. The scope of the instrument for work on activation of colour centres in alkali halides was indicated.

Dr. R. McWeeny gave a brief survey of "New Methods in the Wave Mechanics of Molecules", with emphasis on his recent revision of the valence bond theory (to be published). A molecular wave function may always be constructed from terms which, individually, represent electrons occupying a set of 'orbitals'. The molecular orbital approach employs one such term, the orbitals being non-localized; newer developments admit additional terms representing 'excited configurations'. But the valence bond theory employs localized, atomic orbitals and is essentially a many-term theory, a group of terms corresponding to each possible set of 'chemical bonds'. It is possible to work with such 'structures' only by assuming negligible overlap between different atomic orbitals; but this assumption is now found to be entirely untenable. The new theory employs orthogonalized atomic orbitals, the overlap assumption thereby being properly validated; but the resemblance between this 'valence bond theory' and its predecessor is found to be purely formal, the character, function and interpretation of the valence bond structures being quite new.

Drs. J. A. Abbott and H. C. Bolton presented an account of the theoretical polarizability of the helium atom. The unperturbed ground-state wave function was discussed in terms of junctions arising from different configurations (using the recent work of Taylor and Parr), and the consequent correlation between the positions of the two electrons was shown. The perturbed wave function contains a term proportional to the electric field, and it was shown how this term can be constructed from functions of the right symmetry using the ground-state configurations and the perturbing potential. A variational method was employed to get the best values of the parameters in the perturbed wave-function. With the successive addition of configurations, there was a satisfactory convergence from the lower side on to the true value of polarizability. The method should be suitable for any wave function constructed from configurational functions.

[1] *Proc. Roy. Soc.*, A, **202** 127 (1949); **208**, 277 (1951).

INTERNATIONAL CONFERENCE OF PARAPSYCHOLOGICAL STUDIES

An international Conference of Parapsychological Studies met in Utrecht during July 30–August 5 under the auspices of the University and with the financial support of the Parapsychology Foundation, Inc., of New York. Some sixty members of fourteen nationalities, comprising physicists, chemists, biologists, psychologists, philosophers, engineers and mathematicians took part in discussions of problems which arise in the investigation of those purported types of communication between individuals which are hitherto not explicable in terms of contemporary physics and biology.

After preliminary sessions, four working groups were established: the first dealing with quantitative experimental studies of various classes of alleged paranormal activity; the second with the interpretation of material gathered in psychiatric practice; the third with qualitative and spontaneous (that is, not experimentally controlled) phenomena; and the fourth with the psychological study of those persons who appear to display a large amount of paranormal sensitivity.

Attention was given to the establishment and maintenance of scientific standards, the development of appropriate experimental and quantitative methods, and the most profitable ways in which to combine and extend the concepts and methods of the various sciences in an attempt to understand more fully the relations between the living organism and the environment.

Marked interest was shown at the Conference in the problem of various methods of 'unorthodox' healing, and a medical committee was established and empowered to take preliminary steps towards the organization of an international research centre for the investigation and interpretation of outstanding cases.

At the conclusion of the Conference it was resolved to establish a secretariat and publication centre at the University of Utrecht, a series of committees being charged with arranging subsequent meetings of specialized groups in order to discuss more fully the experimental problems presented. The choice of Utrecht as the centre appears to be appropriate, since in 1951 the University founded an Institute for Parapsychology and in 1953 Dr. W. H. C. Tenhaeff was appointed as professor (*extra-ordinarius*) of parapsychology in the University.

THE MEDICAL RESEARCH COUNCIL

The report of the Medical Research Council for the year 1951–52* is, like its two predecessors, selective, and it is emphasized that it omits many investigations being done by the Council's workers. The scope of the Council's work is nowadays so wide that this omission may be necessary; but some readers will regret that it is so and that we are given no more than the titles of so many interesting lines of research.

The report this year chooses for particular treatment the developments in clinical research, which has, until recently, been almost entirely observational, partly because of the difficulty of devising suitable experimental tests of generalizations derived from observation. Chemical and instrumental tests are, however, now available for use without risk to the patient, and statistical techniques have refined methods of planned observation and controlled clinical trials. Clinical investigation is therefore better able to study groups of sick persons and whole communities.

The Medical Research Council, when it was formed in 1913, gave its chief attention to clinical research, and its first clinical research unit, the Department of

* Committee of Privy Council for Medical Research. Report of the Medical Research Council for the Year 1951–1952. Pp. iv+241. (Cmd. 8876.) (London: H.M. Stationery Office, 1953.) 6s. 6d. net.

Clinical Research at University College Hospital Medical School, London, made important contributions to cardiovascular medicine. But it was Sir Thomas Lewis, a man in advance of his age, who trained a generation of research workers in the application of scientific method to clinical problems, and these men became available in the 1930's, when methods of clinical research were being elaborated. The Ccuncil itself established clinical research units and it is now spending more than £400,000 a year on investigations directly concerned with patients. When the National Health Service Acts gave virtually all facilities for clinical research to the Health Departments, close liaison and unanimous agreement were established between these Departments and the Medical Research Council. It is now proposed that there should be a central organization for the promotion of clinical research, which should be a part of the Medical Research Council, that provision should be made for decentralized research with the greatest possible freedom from supervision and that careers in clinical research should be equated with careers in the National Health Service.

The main interest of scientific readers of this report will no doubt be in the section of it entitled "Some Aspects of Medical Research", which reviews the results obtained by the Council's workers in certain fields. Dr. A. J. P. Martin, of the Division of Physical Chemistry, National Institute for Medical Research, and Dr. R. L. M. Synge, of the Division of Biochemistry, Rowett Institute, Aberdeen, have been jointly awarded the Nobel Prize for chemistry for 1952 for their work on partition chromatography. This section of the report gives an interesting account of the development of chromatography since 1906. Mental deficiency is discussed and the impressive work of the Council's Research Unit on Occupational Psychiatry is described. The Council's work on the causes of maternal and child mortality and on the social aspects of this important subject has as its ideal a pregnant mother who feels well and has a spontaneous and easy labour and gives birth to a lusty child which she is able to feed successfully, and the results obtained have done more for the nation than many people realize. The importance of the glands which produce internal secretions has long been recognized, and the Council's workers at Cambridge who have been studying the close relationships between the central nervous system and the posterior pituitary gland during lactation have shown that the action of sucking excites a nervous reflex in the mother which causes secretion by the posterior pituitary gland and the liberation of a hormone which acts on the mammary glands and causes the 'let down' or ejection of milk. The oxytocic hormone is the most powerful in this respect, and this hormone also stimulates the contraction of the uterine muscle. This work thus provides an explanation of the age-old observation that suckling the young helps the contraction of the uterus after labour. The Cambridge workers are also studying the anterior pituitary gland and the control of the secretion of corticotrophin by this gland.

The section of the report mentioned above also considers work on bacterial food poisoning, the development by bacteria of resistance to drugs, the etiology, mechanism and diagnosis of hæmophilia, hearing-aids and diseases of the ear, the thyroid gland and the uses of radioactive iodine in medicine, the epidemiology, pathology and treatment of poliomyelitis, the physiology of the red blood cells, each of which lives for an average period of 120 days, the synthesis of porphyrins and hæmoglobin in the body and the formation of bile pigment.

The rest of the report provides details of the various units of the Medical Research Council, the names of their staffs and bibliographies of papers published by them and by members of that valuable organization, the Public Health Laboratory Service, and by workers in the Institute of Cancer Research.

All those who work for the Council, whether they are members of the Council itself or are research workers, or perform those unpublicized but highly skilled tasks upon which all modern scientific research depends, deserve the gratitude of the public for whose health and welfare all this devoted work is so patiently and efficiently done. G. LAPAGE

SCIENCE AND FREEDOM

THE International Congress of Science and Freedom held a meeting in Hamburg during July 23–26, which was attended by more than one hundred delegates from nineteen countries, including fourteen from the United Kingdom. The purpose of the meeting was to discuss the danger to cultural freedom which has arisen in totalitarian countries, especially those behind the Iron Curtain. The delegates, among whom were four Nobel laureates, included leading representatives of other branches of learning in addition to science.

The opening session in the Rathaus was addressed by Dr. Max Brauer, mayor of Hamburg, Prof. Bruno Snell, rector of the University, Prof. Denis de Rougemont (Geneva), president of the executive committee of the Congress for Cultural Freedom, Prof. James Franck (Chicago), Prof. J. Pieper (Münster) and Prof. Max Hartmann (Tübingen). The twenty communications which were considered during the meeting included papers by Prof. Michael Polanyi (Manchester) on pure and applied science and their appropriate forms of organization; Dr. J. R. Baker (Oxford) on scientific authority and the system of scientific publications; Prof. S. K. Allison (Chicago) on requirements of security and academic freedom; Prof. T. Dobzhansky (New York) on biology in the U.S.S.R.; Prof. G. v. Rauch (Marburg) and Prof. V. Gitermann (Zurich) on history in the U.S.S.R.; and five papers devoted to "Neutrality or Profession of Faith" and "Moral Responsibility and Science". The various communications aroused much discussion, and it was often difficult for the respective chairmen to keep the speakers to the prescribed time limits.

It was generally agreed that totalitarianism to-day constitutes the greatest and most potent threat to cultural freedom, and the infiltration of Communist ideas into the circles of academic teachers and students has often given rise to a general distrust of the universities as seed-beds of intellectual insubordination. This has led frequently to the demand that universities should recognize without question existing economic and social systems in their respective countries.

The independent position of universities has been further impaired by the fact that they have become increasingly dependent on government grants. These tend to foster those fields of science in which some practical or economic advantage is to be expected. In addition, the Second World War has resulted in the suppression or corruption of many of the older

universities of Europe, with their deeply rooted traditions of academic freedom. This has very seriously diminished the sense of cultural obligation among the public to support the progress of pure science, and it has become rare nowadays to hear the head of a university appealing for funds for the advancement of knowledge as an end in itself.

At the final meeting it was agreed to issue the following message: "At the conclusion of this International Conference in Hamburg on Science and Freedom in which more than 100 scientists and scholars from 19 countries have discussed the theoretical and practical problems of scientific research today, we should like to convey our fraternal greetings to our fellow-scientists separated from us by political power. We are convinced that these, our unhappy colleagues, have never ceased to feel a profound loyalty to those ideals of free inquiry without which science itself would never have arisen. We look forward to the day when they can sit down with us as free men at such a conference as this, to discuss our common problems in a spirit of sincerity and objectivity that they must surely cherish under the most difficult circumstances".

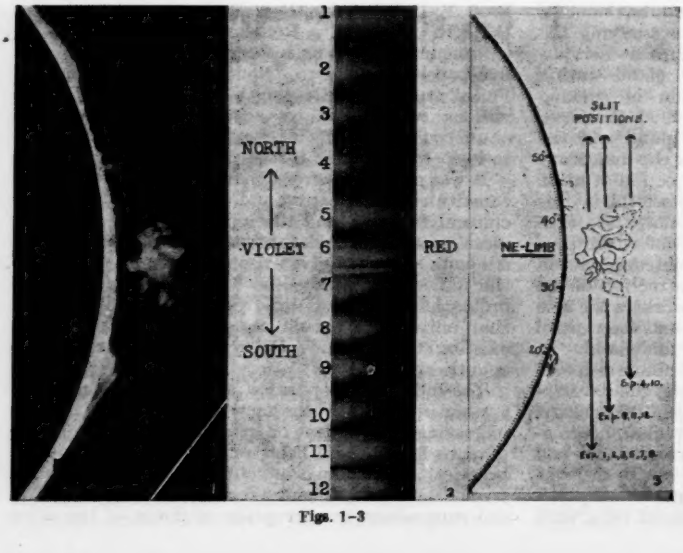
Edward Hindle

ERUPTIVE PROMINENCE OF FEBRUARY 26, 1953, AND ASSOCIATED RADIO NOISE-BURST

After a period of rather pronounced inactivity characteristic of the present minimum phase of the sunspot cycle, an interesting type of activity occurred on February 26. On the previous day a rather insignificant-looking prominence had been observed on the north-east limb at a mean latitude of 40°. On the morning of February 26 visual observations with the spectrohelioscope and photographs obtained with the spectroheliographs between 0200 hr. and 0400 hr. U.T. showed that the prominence had grown somewhat in height and had also extended southwards to about lat. 30°. There was, however, nothing unusual in this, for this increase in size could easily be regarded as the coming into view of parts of the prominence previously behind the limb. There was no visible sunspot in the neighbourhood of the prominence; but the spectroheliograms taken on February 28 and March 1 showed a *plage faculaire* around lat. 22°. Observations during the early hours (0200–0400 hr.) of February 26 showed that the prominence was of the quiescent type.

Between 0400 hr. and 0430 hr. there was no certain sign that the prominence was working up for an eruption, although some slight agitations were noticeable. However, a control observation with the spectroheliosope at 0500 hr. revealed a very different picture: the height of the prominence had grown to 150″, or about double its previous height, and large Doppler displacements were also apparent. At the base the Doppler shifts measured were 1·2 A. towards red (about 55 km./sec.), while the top portions of the prominence were showing displacements of 1·4 A. towards the violet (about 65 km./sec.). Until 0507 hr. the prominence was still adhering to the sun's surface; but from 0510 hr. it broke off from the limb and the next 30 min. saw the most active phase of the eruption. Some parts of the prominence reached a height of 260″, and the maximum Doppler displacement observed in some parts was of the order of 6 A. to red (270 km./sec.). The eruption reached its peak by 0545 hr., after which the prominence—a compact mass until then—began to disintegrate. Two well-developed streamers could be seen descending from the eruptive mass to the sun's surface and exhibiting Doppler shifts of 3–4 A. to violet (135–180 km./sec.), where they met the limb. The ejected prominence matter was apparently being forced back to the sun's surface at lat. 22° through these streamers. By 0700 hr. it became difficult to identify clearly the prominence and its streamers, and in another half-hour the whole phenomenon had subsided leaving no trace of the prominence. From the above description of the course of events this eruptive prominence would probably be classed best as a 'surge' of Class III*d* in Pettit's classification, although it was not visibly associated with a sunspot group.

Luckily the prominence was so located that the spectroheliosope slits were almost exactly tangential to the part of the limb where the prominence was. As our spectroheliosope has no arrangement for rotating the image, this circumstance made it possible to take spectrograms at definite heights in the prominence with the help of the camera[1] attached to the side of the spectroheliosope. Altogether twenty spectrograms were secured in the H_α region with exposure times of 2–4 sec. each. The first twelve of these were obtained between 0535 hr. and 0545 hr. while the prominence was moving away from the limb as a fairly compact mass (Fig. 1). The other eight spectra were photographed between 0620 and 0625 hr. with the first slit of the spectroheliosope cutting across the two streamers; although these spectra also give some interesting information, we shall not consider them in the present communication. The first twelve exposures (Fig. 2) reveal interesting details concerning the



Figs. 1–3

motion and structure of the prominence before disintegration with which we are here concerned. Six exposures (1, 2, 3, 5, 7 and 8) were made on the parts of the prominence nearest to the limb (height above limb 55,000 km.), three exposures (9, 11 and 12) at about the middle (height above limb 85,000 km.) and two exposures (4 and 10) on the topmost parts of the prominence (height above limb 140,000 km.), but exposure No. 6 had just missed the prominence (Fig. 3). In all the eleven serviceable spectra, the strong H_α emission line due to the prominence appears practically as a straight line. Spectra 4 and 10 made on the upper peripheral parts show the bright H_α line shifted towards the violet by about 1 A. parallel to the H_α absorption line of the background; the topmost parts of the prominence, therefore, had a 45-km./sec. velocity of approach in the line of sight. The rest of the spectra, which correspond to the lowest and the middle parts of the prominence, show the bright line intersecting the absorption line, its ends displaced equally by about 1 A. on either side of the absorption line and therefore indicating a rotational velocity of about 45 km./sec. around an axis perpendicular to the line of sight. The sense of the rotation is clockwise as seen from above the prominence.

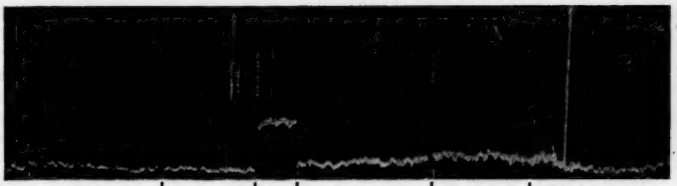


Fig. 4

This prominence therefore had the primary characteristic, namely, rotatory or helical motion, of the tornado type of solar prominence, even though it had neither the columnar nor the crossed lattice-work appearance which is supposed to distinguish the tornado type from other types. However, this particular eruptive prominence seems to have had the properties both of a surge and of a tornado. On one or two occasions in the past we have also noticed a spiral motion around the length of long stable hydrogen absorption markings. It is, of course, not easy to detect observationally such spiral motion in prominences and dark markings, but it probably occurs much more commonly than is believed to be the case. It seems possible to form a purely dynamical picture of the general mechanism of prominence formation in which spiral motion plays a significant part[2].

Another phenomenon to which we would like particularly to direct attention is the occurrence of solar noise bursts in association with this eruptive prominence. On February 26 the radio telescope of this observatory, which works on 100 Mc./s., recorded three bursts of solar noise. The first one occurred between 0450 hr. and 0500 hr., the second, which was stronger, was recorded between 0528 hr. and 0534 hr., and the third, which was the most intense, occurred some time after 0552 hr. (Fig. 4). Unfortunately the recording drum stopped three or four times while the third burst was in progress, and therefore we are not absolutely certain of the times of beginning and ending of this burst. During the first burst the noise intensity suddenly increased at 0450 hr., remained above normal for about ten minutes and then dropped to normal at 0500 hr. without showing the usual series of isolated peaks at short intervals. The second burst showed three separate peaks (although these peaks are unmistakable on the original record, they had to be made more prominent by slight retouching for reproduction purposes). The third and the most intense burst showed three peaks of which the second was apparently the largest. Observations with the *C.R.P.L.* type C_3 ionosphere recorder of this Observatory indicated neither a fade-out nor a marked ionospheric disturbance. The records of our magnetographs (Watson and La Cour) show that the period February 22–March 4 was far from being magnetically quiet; it is therefore impossible to say whether the effects, if any, of the eruptive prominence were obscured or not. Although the sun was under almost continuous optical observation from 0200 hr. until 0730 hr. U.T. on February 26, no indication of a flare was noticed.

It is of interest to note in this context that a solar noise-burst in association with the eruptive prominence of August 7, 1950, was reported by Dodson and Donselman[3], of the McMath-Hulbert Observatory, about two years ago. But there are some important differences between their observations and those reported here. Dodson and Donselman's eruptive prominence was associated with an active sunspot group, whereas there is no evidence of such association in the case of the eruptive prominence of February 26, 1953. A still more significant difference between the two cases is that the noise-burst on 200 Mc./s. occurred when the 1950 prominence had risen to a height of 285,000 km. above the chromosphere, whereas in the case of the 1953 prominence our 100-Mc./s. record showed that the first noise-burst happened simultaneously with the beginning of the eruption, that is, at a moment when the prominence was still on the limb with its topmost parts about 50,000 km. above the limb. The two subsequent bursts occurred when the topmost parts of the prominence were about 140,000 km. and 184,000 km. respectively above the limb. Theoretical considerations indicate that 100-Mc./s. radiation cannot ordinarily escape from the sun unless it is generated at a level higher than 100,000 km. above the sun's surface. The second and third bursts observed in the present case are therefore consistent with present theory. The occurrence of the first burst suggests that perhaps in some yet obscure way the mechanism of eruption itself renders the supernatant atmosphere temporarily more transparent than usual.

A. K. Das
K. Sethumadhavan

Kodaikanal Observatory,
India. May 10.

[1] *Nature*, **164**, 964 (1949).
[2] Das, A. K., *Ind. J. Phys.*, **14**, 369 (1940); **15**, 17 and 79 (1941); **16**, 277 (1942); also *Kodaikanal Obs. Bull.*, No. 127 (1949).
[3] *Astrophys. J.*, **113**, 519 (1951).

Radio Observations at the Time of an Ascending Solar Prominence

Bursts of radio emission are known to be associated with only one type of catastrophic solar activity, namely, chromospheric flares. Radio emission data at the time of occurrence of another type of catas-

trophic phenomenon, an ascending prominence, are then of interest. The ascending prominence of February 26, 1953, described by Das in the accompanying communication, was observed visually in Sydney, and solar emission intensity records on 62, 98, 200, 600, 1,200, 3,000 and 9,400 Mc./s. were obtained at that time.

In the period February 24–28 three well-defined bursts, all of about five minutes duration, were recorded. The first burst at 2320 hr. (U.T.) on February 25 occurred before the prominence erupted. The second was observed on 62, 98 and 200 Mc./s. at 0450 hr. on February 26. It occurred at the time of eruption of the prominence. This burst was also noted at 100 Mc./s. by Das. The third, observed on 62, 98, 200 and 600 Mc./s. at 0630 hr., was the most intense and occurred at the end of the life of the prominence when the material was streaming back towards the sun.

Ionospheric and magnetic data for February 26 showed none of the ultra-violet effects normally associated with flares which could be distinguished above the moderate activity at the time. Also, as there were no sunspots in this period, it is most unlikely that the bursts were associated with flares.

To extend the investigation, a search was made of previous spectroheliograph records. Ascending prominences, each smaller than that under discussion, were observed at 0000 hr. on June 10 and 0500 hr. on July 4, 1952 (private communication from Dr. Giovanelli of the Division of Physics, Commonwealth Scientific and Industrial Research Organization). No radio emission was observed at these times.

It may be concluded that not all ascending prominences give radio emission, although the larger and more eruptive ones may do so. Further radio observations at the time of ascending prominences are therefore desirable.

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Division of Radiophysics,
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June 10.

AN ATTENUATED STRAIN OF THE MYXOMATOSIS VIRUS RECOVERED FROM THE FIELD

By Dr. R. MYKYTOWYCZ

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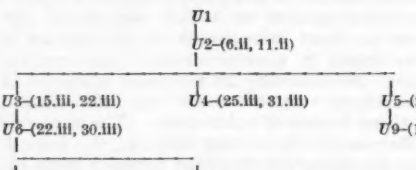
THE epizootic of myxomatosis described by Ratcliffe *et al.*[1], which is now in its third year and has spread to almost every rabbit-infested area in the south-eastern quarter of the Australian continent, was initiated with a strain of the virus that reached Australia from Brazil via the United States and Cambridge. It was the strain *B* of Martin[2], who has given an account of its history and characteristics. Throughout the lengthy experiments of Bull and Mules[3] the virus exhibited great stability and extraordinarily high lethality, death normally supervening on the 10th–12th day with a case mortality-rate of more than 99·5 per cent. My own experience with this strain of the virus has been in line with that of other workers, none of the three hundred odd rabbits (mostly of the wild type) infected with it having recovered.

During the early months of 1953, evidence was obtained by officers of the Wildlife Survey Section of the Commonwealth Scientific and Industrial Research Organization, working in collaboration with the Microbiology Department of the Australian National University, that there had been a significant decrease in the case mortality-rate of the disease in certain localities. The recovery, here recorded, of an attenuated strain of the virus from the field suggests that modification of the virus may be an important factor in the process of host–parasite adjustment that is apparently now taking place.

On February 6, two wild rabbits were brought into this laboratory from near Uriarra in the Australian Capital Territory. Myxomatosis was active at the time on the property from which the rabbits were obtained. It had been established in the immediate neighbourhood early in 1951, since when (augmented by further liberations) the infection had maintained itself in the Territory at a varying level of intensity. One of the two Uriarra rabbits was healthy; the other, a half-grown individual, had the appearance of being on the way to recovery from the disease. They were kept together in one cage. On February 15 the infected rabbit was found dead. In the interval, however, its condition had improved markedly, the eyes having opened and the swellings on the eyelids, the perineal region, and elsewhere on the body having subsided.

The second rabbit had developed symptoms of generalized myxomatosis on February 11; and when it was obvious that the disease was running an atypical and prolonged course, it was decided to passage the virus for further study. This rabbit (*U*2) was killed by a cage-mate on March 30, that is, forty-eight days after generalization.

The relation of the passages carried out is indicated in the diagram below. Infection was brought about in every instance by placing a healthy wild rabbit in a cage with a diseased animal, the period of contact ranging from 16 to 24 hours. The first date given is that of the contact, the second that of the appearance of the symptoms of generalization.



Not one of the eight animals infected with the virus from the original Uriarra rabbit has, to date (May 4, 1953), succumbed to the disease. In addition to the one killed by a cage-mate, one (*U*3) was sacrificed for serological study.

In four animals (*U*2, *U*4, *U*6 and *U*9) the onset of the disease was severe, typical symptoms developing and increasing up to about the tenth day after generalization. After that the swelling of the anus and the external genital organs regressed, leaving extensive scars; but the lesions of the eyelids, accompanied by discharge from the eyes, persisted for a considerable time. A point of interest was that rabbit *U*2 was found to be capable of passing on

the infection throughout its prolonged illness, being in contact with *U3* on the thirty-second, *U4* on the forty-second, and *U5* on the forty-seventh day after generalization.

The character of the disease in rabbits *U5*, *U7* and *U8* was very much milder. The eyelids and face developed discrete swellings, but no general œdematous enlargement. The eyes did not close, nor did they discharge. The perineal region did not become greatly swollen. Three weeks after generalization all swelling had subsided, scars only marking the sites of the larger tumours. The animals never lost condition, and remained fit enough to fight their cage-mates.

Rabbit *U3* was outstanding in the mildness of its infection; in fact, myxomatosis could scarcely have been diagnosed from the clinical symptoms. Generalization was marked by a very slight inflammation of the eyelids, anus and preputium. Later, the only indication of lesions, which had produced no palpable swellings, were ruffled fur around the base of the ears and on the front of the face. When the animal was sacrificed eight days after generalization, the only signs of infection were numerous small lesions on the skin of the body, a very slight asymmetrical swelling of the genital organs, and some small tumours on the upper eyelids, the top of the nose, and at the bases of the ears.

The case-histories of the animals used in this study indicate that a modified strain of lowered virulence has appeared in the field. The possibility of all the experimental rabbits possessing an enhanced genetic resistance seems too remote for serious consideration: they were obtained from different parts of the Territory and, moreover, Prof. Fenner[4] reports that the Uriarra strain of the virus is producing an atypical disease in laboratory rabbits, which, of course, come from a population without a previous history of contact with the infection.

Two variants of the myxomatosis virus of greatly reduced virulence have appeared in the laboratory, Hurst's[5] neuromyxoma and Berry's[6] strain 80*A*. This is the first recorded recovery from an epizootic in a wild rabbit population of a strain of the virus modified to a degree comparable with these two laboratory variants. I have also indications, based on the observation of naturally infected rabbits, of the occurrence of atypical mild infections in two other localities within the Australian Capital Territory; and Fenner[7] now has evidence that somewhat attenuated strains may have appeared in the field in other parts of Australia. [May 4.

(*Note added in proof. July* 21.) Since the above report was written, the passaging, by contact infection, of the Uriarra 'strain' of the myxoma virus has been continued. Five more rabbits have made complete recoveries, while one animal (which proved to be heavily infected with coccidia) has succumbed. However, virus recovered from mild cases, and inoculated into test animals for various purposes, has failed to produce the non-lethal disease characteristic of the contact-infection series. Thus the overwhelming majority of the animals infected by mosquitoes that had fed on a rabbit inoculated with material from rabbit No. *U3* have died, though these fatal infections have been rather atypical[8].

It is not easy to see how the mere difference in the mechanism of infection (that is, by contact—whatever this may involve—and by intradermal inoculation or mosquito bite) could provide a satisfactory explanation of these contrasting results. It has been suggested[9] that the Uriarra 'strain' is a mixture of strains including a variant of low virulence, the complex character of which has somehow been maintained through the series of contact infections. Information on the behaviour of infections by more than one strain of the myxoma virus appears to be limited to the results of some experiments by Dr. L. B. Bull[10], who used Martin's strain *B* and Hurst's neuromyxoma. The disease produced was mild, although only fully virulent virus was recovered from the animals that had been simultaneously infected by both strains.

[1] Ratcliffe, F. N., Myers, K., Fennessy, B. V., and Calaby, J. H., *Nature*, **170**, 7 (1952).
[2] Martin, C. J., Univ. of Cambridge Inst. Anim. Path. Fourth Report, 16 (1934–35).
[3] Bull, L. B., and Mules, M. W., *J. Coun. Sci. and Indust. Res.*, **17**, 79 (1944).
[4] Fenner, F. (personal communication).
[5] Hurst, E. W., *Brit. J. Exp. Path.*, **18**, 15 (1937).
[6] Berry, G. P., *J. Bact.*, **36**, 285 (1938).
[7] Fenner, F., *Nature* [**172**, 228 (1953)].
[8] Day, M. F., and Mykytowycz, R. (unpublished data).
[9] Ratcliffe, F. N. (personal discussion).
[10] Bull, L. B. (unpublished data).

EXPLOSIONS IN MIXTURES OF HYDROGEN, CHLORINE AND NITROGEN TRICHLORIDE

By Dr. P. G. ASHMORE

Department of Physical Chemistry, University of Cambridge

IT is well known that nitrogen trichloride will inhibit the photochemical reaction between hydrogen and chlorine when the total pressure of the reactants is about atmospheric. We have recently shown, on the other hand, that at low pressures traces of nitrogen trichloride cause an explosive combination of the hydrogen and chlorine in the dark after an induction period. These low-pressure, low-temperature explosions have been examined by making up mixtures of nitrogen trichloride, chlorine and hydrogen, and of nitrogen trichloride, chlorine and nitrogen for comparison, at high pressures, and then admitting a selected pressure of the chosen mixture to an evacuated reaction vessel. This vessel was cylindrical, of internal diameter 30 mm., and was held in a thermostat and shielded from light. Explosions of mixtures of hydrogen, chlorine and nitrogen trichloride were accompanied by a bright flash and were audible; when nitrogen replaced the hydrogen, the explosion was extremely faint, but a sharp kick was registered on the Bourdon gauge and was attributed to the explosive decomposition[2] of the nitrogen trichloride. Whenever slow decomposition of the nitrogen trichloride occurred, it was followed by the accompanying pressure change due to the overall reaction: $2NCl_3 \rightarrow N_2 + 3Cl_2$. After a reaction in mixtures of hydrogen, chlorine and nitrogen trichloride, the gases were withdrawn through spirals surrounded with liquid nitrogen, so that the amount of hydrogen chloride formed could be estimated.

The nitrogen trichloride was prepared by running excess of chlorine into a mixture of ammonia and hydrogen or nitrogen. The addition of the hydrogen or nitrogen keeps the pressure above the upper limit

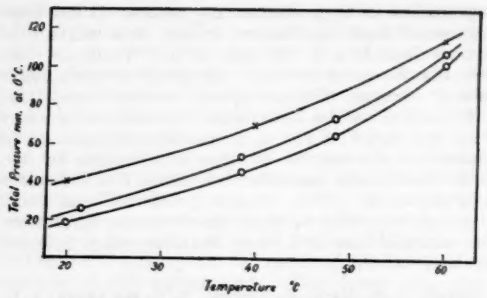


Fig. 1. Variation of the upper limit of ignition with temperature. Bottom curve for equimolar nitrogen and chlorine, middle curve for equimolar hydrogen and chlorine, each with about 1 per cent nitrogen trichloride; the top curve gives Apin's values for nitrogen trichloride alone

for explosion at room temperature (see Fig. 1), so preventing the ignitions sometimes observed[1] when chlorine is run into ammonia alone. Very little of the hydrogen used as a diluent was converted to hydrogen chloride; this result would be expected from the molecular mechanism usually postulated for the reaction: $4NH_3 + 3Cl_2 \rightarrow NCl_3 + 3NH_4Cl$.

The principal results observed were as follows:

(1) Explosions occur in both the hydrogen, chlorine, nitrogen trichloride system and the nitrogen, chlorine, nitrogen trichloride system below a reproducible pressure (the upper limit). Experiments were not made to investigate any possible lower limit.

(2) The upper limit appears to be independent of the proportion of nitrogen trichloride in the mixtures, once this is above 0·1 per cent, up to the highest proportion used (2·0 per cent).

(3) The upper limit varies with temperature as shown in Fig. 1, where the curves for hydrogen plus chlorine and for nitrogen plus chlorine in the presence of 1 per cent of nitrogen trichloride are compared with the curve for nitrogen trichloride alone as determined by Apin[2].

(4) Below the upper limit, the hydrogen and chlorine in mixtures of hydrogen, chlorine and nitrogen trichloride are converted completely to hydrogen chloride; immediately above, the proportion converted falls abruptly to zero. In nitrogen, chlorine, nitrogen trichloride mixtures, the nitrogen trichloride decomposes explosively and completely at pressures below the upper limit.

(5) For both mixtures the rate of decomposition of the nitrogen trichloride at pressures just above

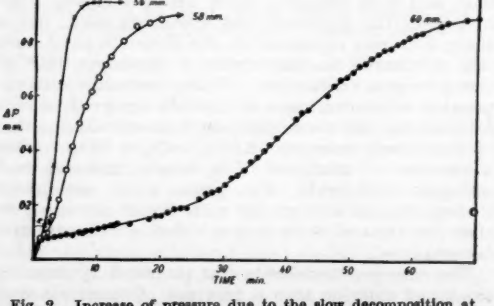


Fig. 2. Increase of pressure due to the slow decomposition at 38·4° C. of nitrogen trichloride in the presence of equimolar mixtures of hydrogen and chlorine at pressures (shown in mm. at 0° C.) just above the upper limit (55 mm.)

the upper limit follows an *S*-shaped curve; as the total pressure increases, the maximum rate falls off very rapidly and the time elapsing before the maximum rate is reached increases greatly. Typical results are shown in Fig. 2.

(6) There is an induction period before all explosions which presumably corresponds to the time taken by the decomposition of the nitrogen trichloride to reach its maximum rate. The induction period increases rapidly but smoothly as the pressure increases through the upper limit.

(7) Traces of nitrosyl chloride eliminate the explosions in hydrogen, chlorine, nitrogen trichloride and in nitrogen, chlorine, nitrogen trichloride mixtures. This is probably due to rapid reactions such as:

$$NOCl + Cl \rightarrow NO + Cl_2,$$

which remove the chain centres responsible for the explosive decomposition of the nitrogen trichloride.

(8) A few runs with methane in place of hydrogen showed that it was chlorinated rapidly below an upper pressure limit; there was no visible ignition, but there was a very strong kick on the Bourdon gauge.

The parallel behaviour of the systems hydrogen, chlorine, nitrogen trichloride and nitrogen, chlorine, nitrogen trichloride suggests that the explosive combination of the hydrogen and chlorine is triggered by centres provided by the thermal decomposition of the nitrogen trichloride. In order to account for the upper limits observed in these experiments and by Apin, the thermal decomposition must be assumed to proceed by a branched-chain mechanism. Norrish and Griffiths[1] suggested that the chlorine-photosensitized decomposition involved the propagating steps:

$$Cl + NCl_3 \xrightarrow{k_1} NCl_2 + Cl_2$$

and

$$NCl_2 + NCl_3 \xrightarrow{k_2} N_2 + 2Cl_2 + Cl,$$

and the terminating step

$$Cl + NCl_3 + M \xrightarrow{k_T} NCl_4 + M.$$

In the thermal decomposition, the chain-initiating step is probably:

$$NCl_3 \xrightarrow{k_1} NCl_2 + Cl.$$

This is followed by the two propagating steps, the the second of which is highly exothermic and might occasionally take the course

$$NCl_2 + NCl_3 \xrightarrow{k_B} N_2 + Cl_2 + 3Cl$$

and so give positive branching. The competition between reactions k_B and k_T leads to an upper pressure limit P_U given by:

$$P_U (k_T' f' + k_T'' f'' + \ldots.) = k_B \frac{k_2}{k_3},$$

where f', f'', etc., are the mole fractions of the gases in the mixtures and k_T', k_T'', etc., the corresponding velocity constants for the chain-terminating steps. The upper limit is thus independent of nitrogen trichloride, as observed experimentally, but varies with the composition of the mixture.

I am grateful to Prof. R. G. W. Norrish and to Prof. F. S. Dainton for many stimulating discussions about this work. [Feb. 27.

[1] Griffiths, J. G. A., and Norrish, R. G. W., *Proc. Roy. Soc.*, A, **130**, 591 (1931).

[2] Apin, A. J., *Acta Physicochim. U.R.S.S.*, **12**, 406 (1940).

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents

Hæmoglobin in Protozoa

THE presence of hæmoglobin in the ciliate *Paramecium caudatum* was discovered by Sato and Tamiya[1]. This is the first, and so far the only, record of the occurrence of hæmoglobin in Protozoa, one of the largest phyla of the animal kingdom.

In the course of our study of the structure and properties of cytochrome in micro-organisms, we were able to confirm Sato and Tamiya's observations on *Paramecium*, to extend them to another ciliate *Tetrahymena* (*Glaucoma*) *pyriformis*, and to determine the concentration of hæmoglobin in both ciliates. Our study of *Paramecium caudatum* was based upon cultures of this ciliate kindly provided by Dr. P. N. Ganapati. The ciliate was cultivated for 14 days at 24° in a bacteria-free medium containing a suspension of the yeast *Torula utilis* in half-saturated calcium sulphate solution. A suspension of *Paramecium* freed from yeast was concentrated by centrifugation; the supernatant fluid was rapidly decanted leaving a cake of ciliates which was pink by reflected light and distinctly red by transmitted light. Spectroscopic examination of a well-aerated suspension of this ciliate showed two strong absorption bands of oxyhæmoglobin at about 582 and 545 mμ which, when aeration was interrupted, disappeared and were replaced by the bands of the reduced components of cytochrome. In an aerated suspension treated with cyanide the α-band (582 mμ) of oxyhæmoglobin could be seen together with the bands of the reduced components of cytochrome, while the β-band (545 mμ) was somewhat modified by the appearance of the α-band of cytochrome *c* (550 mμ). On passing through the suspension a current of a gas mixture $CO/O_2 = 4$, the bands of oxyhæmoglobin were replaced by two more diffuse but still very distinct bands of CO-hæmoglobin lying at about 574 and 539 mμ. When the current of gas mixture was interrupted, the band at 574 mμ remained visible together with the bands of reduced cytochrome. On treating the suspension of *Paramecium* with an oxidizing agent such as quinone, the absorption bands of oxyhæmoglobin disappeared and were replaced by the weak band at 635 mμ of acid methæmoglobin.

In a similar way we were able to demonstrate the presence of hæmoglobin in another ciliate, *Tetrahymena pyriformis* (GL.), the strain of which was kindly supplied by Dr. E. G. Pringsheim. This was the strain described by Lwoff[2] under the name of "*Glaucoma piriformis*" and reclassified by Corliss[3]. The organism was cultivated at 30° in two to four litres of sterile medium containing 1 per cent peptone and 0·4 per cent sodium chloride, harvested after six days of growth, using a small angle centrifuge, and resuspended either in 0·45 per cent sodium chloride or in Ringer-phosphate solution[4]. Aerated suspensions of *Tetrahymena* showed a weak but distinct α-band of oxyhæmoglobin at about 582 mμ which was somewhat masked by the absorption bands of cytochrome. The formation of carbon monoxide hæmoglobin and of methæmoglobin was recognized by the disappearance of the bands of oxyhæmoglobin in the presence of carbon monoxide or quinone respectively, rather than by the appearance of the characteristic bands of these derivatives. It may be noted that Baker and Baumberger[5], who studied the absorption spectrum of cytochrome in *Tetrahymena geleii* (*Tetrahymena pyriformis* (T.)[3]), failed to record the presence of hæmoglobin in this ciliate. However, the fact that they refer to the observations of Sato and Tamiya on hæmoglobin in *Paramecium* suggests that either hæmoglobin was completely absent in their cultures of *Tetrahymena* or present in much too low concentration to be easily recognized.

The concentration of oxyhæmoglobin in *Paramecium* and *Tetrahymena* was determined by comparing the intensity of their absorption bands with those of a standard solution of oxyhæmoglobin. A flat-bottomed tube containing a thick suspension of ciliates was placed on the stage of the microspectroscope; the tube was surrounded with ice to slow down the respiratory activity of the cells, and therefore the deoxygenation of hæmoglobin. A little tributyl citrate was added to the suspension to prevent frothing during aeration, and the absorption spectrum of oxyhæmoglobin in the tube was matched against that of a standard solution of oxyhæmoglobin placed in one of the compartments of a double wedge trough[6]. The hæmoglobin content of *Paramecium* was also estimated as the carbon monoxide hæmoglobin derivative, the absorption spectrum of which, although not as strong as that of oxyhæmoglobin, is nevertheless very distinct and more stable than the latter. Moreover, carbon monoxide protects hæmoglobin from slow oxidation to methæmoglobin. This method was not, however, applicable to the study of *Tetrahymena*, the hæmoglobin content of which was too low for the proper observation of its carbon monoxide derivative.

The hæmatin content of the ciliates was determined as pyridine hæmochromogen, the absorption bands of which were matched with a standard solution of pyridine hæmochromogen prepared from pure hæmin. Assuming that the equivalent weight of hæmoglobin in ciliates is about 17,000, the hæmoglobin content of *Paramecium* from several batches of culture gave values (on a dry-weight basis) varying between 1·12 and 1·74 per cent, which correspond to a hæmatin content of 0·043–0·067 per cent. On the other hand, the hæmatin content estimated as pyridine hæmochromogen was found to vary between 0·088 and 0·11 per cent; the excess of hæmatin thus estimated belongs to other hæmoproteins present in the cells.

The hæmoglobin content of *Tetrahymena pyriformis* (GL.) estimated as oxyhæmoglobin was found to vary between 0·22 and 0·3 per cent, which corresponds to a hæmatin content of 0·008–0·012 per cent, whereas the total hæmatin content estimated as pyridine hæmochromogen was found to be between 0·025 and 0·035 per cent.

The presence of hæmoglobin in two very common ciliates, *Paramecium caudatum* and *Tetrahymena pyriformis*, suggests the possibility that hæmoglobin may have a much wider distribution in Protozoa than was hitherto suspected. However, this problem can be solved only by careful spectroscopic examination of thick suspensions of these organisms. Unfortunately, pure mass-cultures of Protozoa are often very difficult to obtain.

This work was carried out while one of us (J. F. R.) held a Medical Research Council studentship.

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Factors modifying the Influence of Light on Germination

Within the temperature-range of 20–30° C. a higher percentage of lettuce seeds, var. Grand Rapids, germinates after irradiation with red light within the range of 6000–7000 A. than in the dark. At about 18° C., in darkness, the percentage of germination is high and cannot be further increased by red light. Above 32° C. the percentage of germination is nil in darkness, and cannot be increased by red light. Within these temperature limits the maximum relative effect of red light on germination is reached at approximately 26° C. This phenomenon appears to be frequent among different species of seed, although the temperature-range within which the light-sensitivity of germination is exhibited varies with the species in question[1].

The effect of red light on germination can be counteracted by radiation of longer wave-length, between 7000–8200 A. As Borthwick, Hendricks and co-workers have shown[2], the maximum stimulating effect of red light occurs at about 6600 A., the maximum inhibiting effect of infra-red radiation at approximately 7300 A.

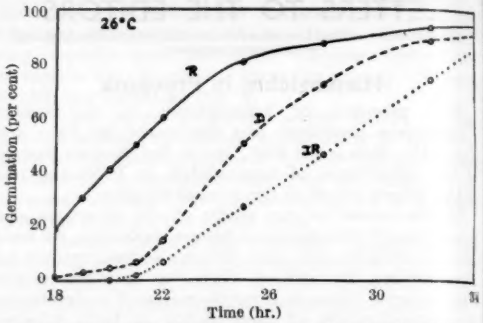
Recently, we proposed a mechanism[3] which might account for the known effects of light, temperature and possibly chemical agents (such as oxygen, coumarine and thiourea) on germination in so far as these effects are connected with the same mechanism, and attempted to find a connexion between these effects in the case of germination and in other biological processes where, as Kelner[4] and Dulbecco[5] have shown, similar effects occur.

We have now investigated whether irradiation with the inhibiting infra-red light (IR) has an effect on seeds which have undergone imbibition in the dark and have not been treated with red light. As shown in Table 1, pretreatment with the infra-red light reduces the percentage of germination below that of the 'dark-control' (D) (that is, seeds germinating throughout in darkness). The percentage of germination thus reached is, within the experimental error, identical with the value obtained when seeds after imbibition in the dark are first stimulated with red light and then inhibited with infra-red. For comparison reference may be made to the results of others[6] who have shown that pretreatment with infra-red influenced the effect of ultra-violet or X-ray irradiation following on it, without having by itself an observable biological effect in those cases (for example, *Drosophila*, *Tradescantia* and *Aspergillus terreus*). In our case, also, when the increase in the percentage of germination due to the treatment with red light (R) is measured (that is, the values of (R minus D) and (R minus IR) respectively are compared) there is a relative increase in this effect of the red light after treatment with infra-red. In addition, one is able to point out the biological process directly affected by the infra-red in the present case.

Using infra-red irradiation either on 'dark' seeds or on those previously irradiated with red light, it

Table 1. Lettuce Seeds, var. Grand Rapids. Percentage of Germination at 26° C.
D, 'dark-control'. Imbibition and germination in dark; R, irradiation with red light interposed between imbibition and germination in dark; IR, irradiation with infra-red interposed; IRR, infra-red, followed by red, interposed; RIR, red, followed by infra-red, interposed

	D	R	IR	IRR	RIR
%	28 ± 5·2	76 ± 5·0	12 ± 3·7	72 ± 6·7	15 ± 5·8



Dependence of percentage of germination on time since imbibition. Percentages in terms of seeds germinating up to 48 hr. after imbibition. D, 'dark-controls'; R, irradiated with red light; IR, irradiated with infra-red light

was found that the percentage of germination may be lowered to one and the same limit, which is determined by the temperature at which the experiment is carried out. Using red light either on 'dark' seeds or on seeds pretreated with infra-red light, the percentage of germination may be raised to an upper limit, which is again a function of the temperature. These temperature-dependent limits are shown in Table 2.

Table 2. Lower and Upper Temperature-determined Limits of Percentage of Germination

Temp. ° C.	Lower limit (per cent)	Upper limit (per cent)
20	32 ± 5	88 ± 3
26	14 ± 3	74 ± 2
30	0 ± 1	35 ± 6

One possible interpretation is that the existence of the two limits points to the operation of two mechanisms determining the percentage of germination. One of these mechanisms is not affected by light and operates up to the limit below which the percentage of germination cannot be reduced by light alone. The other mechanism is the light-sensitive one responding to the opposing effects of red and infra-red and operates up to the temperature-dependent upper limit beyond which germination cannot be increased by light alone. The effect of infra-red irradiation on 'dark' seeds is then due to the existence to some extent of the light-sensitive system in the 'dark' seeds, possibly owing to the fact that even before imbibition these seeds contain moisture in equilibrium with the moisture content of the air[7].

This view of two mechanisms leading to germination in the light-sensitive seeds is supported by the results shown in the graph, which indicate that the specific velocity of the germination process is higher in seeds which germinate as the result of the influence of irradiation with red light, and lower in those seeds germinating as the result of the light-independent process. The 'dark' seeds show a composite behaviour.

These results do not permit us to distinguish between the alternatives: whether the physico-chemical system subject to the inhibiting effect of the infra-red is immediately related to the one produced by the action of the red light or separated from this step by additional intervening biochemical processes. Table 3 shows that the inhibiting effect of infra-red appears to be greatest when it is applied immediately after irradiation with red light, indicating the absence of intervening biochemical steps, and

Table 3. EFFECT OF DELAY IN APPLYING INFRA-RED AFTER RED ON THE PERCENTAGE OF GERMINATION

	Red alone	Infra-red applied t minutes after red				
		t	0	30	45	60
Per cent of germination	71		15	19	24	31

supporting the mechanism previously suggested[3] according to which it is the system formed by the action of the red light which is sensitive to the effect of the infra-red.

The full details of these and other related experiments will be published elsewhere.

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Direct Deamination of Adenosine Diphosphate by Washed Myofibrils

THE deamination of adenine nucleotides by homogenates and extracts of skeletal muscle is usually ascribed to the action of an enzyme, originally described by Schmidt[1], which specifically deaminates adenosine monophosphate. Direct deamination of adenosine triphosphate has not been demonstrated, though the work of Banga and Josepovits[2] suggested a simultaneous production of inorganic phosphate and ammonia from adenosine diphosphate. This effect required the presence of myosin plus a 'protin' preparation, and an isomer of adenosine diphosphate was postulated as an intermediate compound. This claim has been criticized adversely by Bailey[3].

Evidence supporting the possibility of a direct deamination of adenosine diphosphate has now been obtained. Muscular tissue (psoas, longissimus dorsi and thigh muscles) from the rabbit was used in these investigations. It was homogenized with a high-speed homogenizer to the myofibril-level, centrifuged, washed and recentrifuged repeatedly. For this procedure, 0·16 *M* potassium chloride, acetate buffer (0·2 *M*, *p*H 5·5) or borate buffer (0·1 *M*, *p*H 8·6) were all found to be suitable. The fibrils were finally suspended in acetate or veronal buffer (*p*H 5·5–6·0) and stored at 0° C.

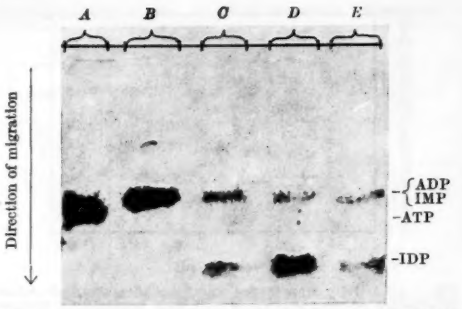
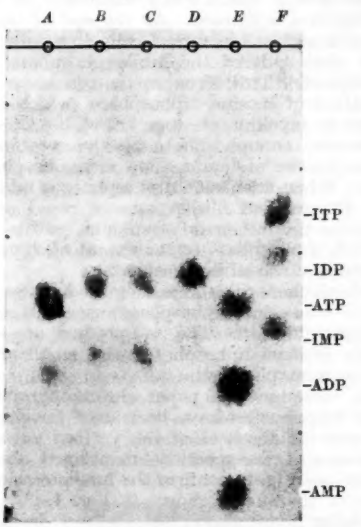


Fig. 2. (*a*) Ionophoretic analysis of reaction products (refer to Fig. 1,*a*). Potential gradient approx. 16 V./cm. for 2–3 hr., citrate buffer (0·1 *M*, *p*H 3·0), Whatman paper 3 MM. *A*, *B*, *C*, *D*, reaction times 0, 5, 30, 60 min. respectively. *E*, inosine mono- and di-phosphate markers.



(*b*) Chromatographic analysis of reaction products (refer to Fig. 1,*a*). *A*, time 0 min.; *B*, time 60 min.; *C*, time 60 min. + inosine monophosphate; *D*, time 60 min. + inosine diphosphate; *E*, adenosine mono-, di- and triphosphate markers; *F*, inosine tri-, di- and monophosphate markers (propanol/ammonium hydroxide/water, 60/30/10, as solvent)

Fig. 1 shows the effect of adding either (*a*) adenosine triphosphate, or (*b*) adenosine diphosphate to such a fibril suspension. With adenosine triphosphate, there is a rapid hydrolysis of the terminal phosphate group, followed by a slow dismutation of adenosine diphosphate due to residual myokinase acting at a *p*H well below its optimum. The production of ammonia

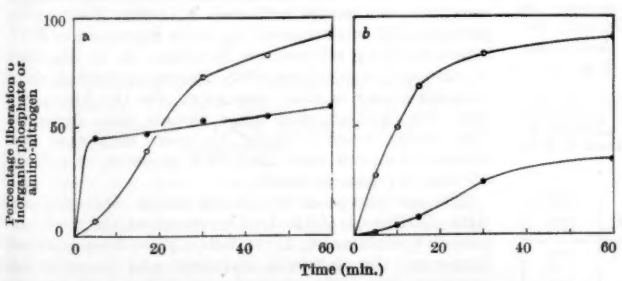


Fig. 1. Washed myofibrils (equivalent to 0·8 gm. original muscle), acetate buffer (0·05 *M*, *p*H 5·5), cysteine (0·01 *M*), room temperature.

(*a*) Adenosine triphosphate added (13·9 μM). (*b*) Adenosine diphosphate added (7·4 μM). ○, Amino-nitrogen liberated. ●, Inorganic phosphate liberated

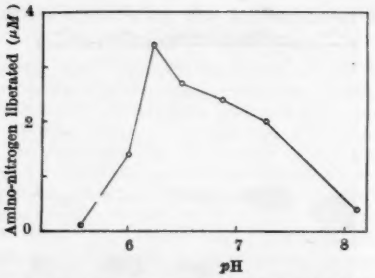


Fig. 3. *p*H activity curve for deamination of adenosine diphosphate in presence of versene (0·01 *M*). Muscle equivalent 0·63 gm., veronal buffer (0·03 *M*), adenosine diphosphate (7·4 μ*M*), 30 min. incubation at room temperature. (Liberated inorganic phosphorus found to be zero at all *p*H values)

begins slowly but rapidly increases as adenosine diphosphate is formed. At the end of the reaction period deamination is practically complete; but little more than half of the labile phosphate has been hydrolysed. This situation is consistent with the formation of inosine diphosphate (which is not dismuted by myokinase[4]), together with a small amount of inosine monophosphate by the combined action of myokinase and adenosine monophosphate-deaminase. When adenosine diphosphate is added originally, the washed fibrils cause a rapid and nearly complete production of ammonia, and a slow production of phosphate to the extent of approximately one-third of the labile phosphate.

In both these cases, it is suggested, direct deamination of adenosine diphosphate occurs, together with some dismutation. The end-product appears to be mainly inosine diphosphate, with small amounts of inosine monophosphate.

The techniques of paper chromatography and of paper ionophoresis have been used for checking the presence (or absence) of the various nucleotides at all stages of the reactions mentioned above. The results (see Fig. 2) confirm the interpretation already given of the curves shown in Fig. 1.

A fuller investigation of the direct deamination of adenosine diphosphate disclosed by these experiments is complicated by its dismutation caused by myokinase. The accompanying table shows the effect of *p*H on the relation between dismutation and deamination of adenosine diphosphate. Increase of *p*H from 5 to 7 progressively favours dismutation, and inosine monophosphate ultimately replaces the diphosphate as the main end-product. It was, however, found that 'versene' (ethylene diamine tetra-acetate), at a concentration of 0·01 *M*, prevented dismutation at all values of *p*H, without affecting deamination. In the presence of this reagent, the *p*H-optimum for the activity of adenosine diphosphate deaminase was found to be approximately 6·2 (see Fig. 3).

Effect of *p*H on Relation between Deamination and Dismutation of Adenosine Diphosphate by Washed Myofibrils. Muscle equivalent 0·6 gm., veronal buffer (0·03 *M*), adenosine diphosphate (10·3 μ*M*), room temperature. Reaction allowed to go to completion

*p*H	ΔP	ΔN	IMP formed (ΔP)	IDP formed (ΔN—ΔP)	Ratio $\frac{\text{IDP}}{\text{IMP}}$
5·1	2·5	9·1	2·5	6·6	2·6
5·4	3·6	9·3	3·6	5·7	1·6
5·9	6·7	9·3	6·7	2·6	0·4
6·2	7·6	9·6	7·6	2·0	0·3
7·0	10·3	9·8	10·3	−0·5	—

Expressed in μ*M*

It has proved impossible so far to measure the effect of calcium and magnesium ions on the deamination of adenosine diphosphate, because these ions, particularly magnesium, progressively stimulate dismutation as their concentration is increased up to 0·005 *M*. Cysteine (0·01 *M*) is found to activate deamination strongly, iodoacetate (0·01 *M*) has little effect, while fluoride and selenite (0·01 *M*) halve its activity.

Homogenized, washed rabbit heart muscle does not exhibit adenosine diphosphate-deaminase activity, neither do preparations of actin or myosin.

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June 12.

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Influence of Cysteinamine, Methylamine and Cortisone on the Toxicity and Activity of Nitrogen Mustard

According to Bacq and Herve[1,2], cysteinamine (2-mercaptoethylamine) and methylamine protect mice against a lethal dose of X-irradiation. The amines prevent death, but do not inhibit X-ray damage to the testes. It was tempting, therefore, to see whether they reduce the toxicity of a 'radiomimetic' drug[3] without at the same time reducing its specific activity. Colter and Quastel[4] have already shown that, *in vitro*, methylamine protects choline oxidase against nitrogen mustard.

On the first day of the experiment, female rats of 51 ± 5·8 gm. mean body-weight received a subcutaneous transplant of Walker carcinosarcoma. Treatment was started on the second day with various doses, per 100 gm. body-weight, of methyl-*bis*-(2-chloroethyl)amine hydrochloride (*HN*2) given intraperitoneally in 0·4 ml. of distilled water. In each experiment approximately half of the animals were given previous injections of cysteinamine, methylamine or cortisone acetate. The cysteinamine and methylamine were given intraperitoneally in 0·2 or 0·3 ml. of distilled water per rat, the solution being made up immediately before use. A suspension of 0·125 gm. of cortisone acetate (cortone acetate) was injected subcutaneously twice a day with an interval of six hours between injections. The nitrogen mustard was given half-way between the two injections. All rats received ten daily injections of *HN*2, intervals being allowed on Sundays, or, in imitation of clinical timing, four daily injections with a day's interval after the third injection. On the fourteenth day, the tumours and other tissues were dissected. The mean weight ratios between untreated and treated tumours were used as a measure of activity of the nitrogen mustard.

The results are shown in the table. Rats injected with *LD*100 of *HN*2 died even when they had received cysteinamine three hours previously. When, however, the interval between the injection of cysteinamine and mustard was reduced to half an hour, 50 per cent protection was afforded.

*HN*2 is more toxic to tumour-bearing than to normal rats[5]. When injected, for example, with a daily dose

TOXICITY AND ACTIVITY OF METHYL-*bis*-(2-CHLOROETHYL)AMINE HYDROCHLORIDE (*HN*2) ALONE AND AFTER COMBINED TREATMENT

*HN*2 (mgm./kgm./day)	Addition agent	Treatment (mgm./rat/day)	Interval between injections (hr.)	Duration of treatment (days)	No. of deaths		Tumour-inhibiting activity		
					Combined	*HN*2	Combined treatment (ratio)	*HN*2 only (ratio)	Significance of the difference (*P*)
1·0	Cysteinamine	2·5	3	4	12/12	12/12	—	—	—
1·0	,,	2·5	1/2	4	6/12	12/12	—	—	—
0·5	,,	2·5	3	4	0/10	4/10	63·9	22·1	< 0·05 > 0·01
0·5	,,	2·5	3	4	1/11	5/11	17·1	18·6	—
0·2	,,	3·0	6	10	0	0	51·7	7·5	< 0·01
0·2	,,	3·0	6	10	0	0	42·0	5·9	< 0·01
0·5	Methylamine	2·0	3	4	4/11	4/10	14·1	22·1	0·6
0·2	,,	2·0	6	10	0	0	10·4	6·4	0·3
0·5	Cortone	0·25	3	4	10/12	4/10	—	22·1	—

of 0·5 mgm./kgm. on four days, normal female rats survived the fourteen days period of the test, whereas a number of tumour-bearers died. However, when this dose was administered three hours after an injection of cysteinamine, protection amounting to almost 100 per cent was afforded.

The tumour-inhibitory activity of *HN*2 was not reduced by the supplementary use of cysteinamine; on the contrary, in one duplicate test the activity of the mustard seemed to be increased. In a further duplicate experiment in which cysteinamine was given six hours before a non-lethal dose of *HN*2, the use of the combined treatment resulted in a sevenfold increase in the tumour-inhibitory activity of *HN*2. This potentiation of the tumour-inhibitory effect was accompanied by an 18–41 per cent greater effect of *HN*2 on the spleen-weight. Cysteinamine *per se* (104 mgm./kgm. distributed over ten daily injections) caused shrinkage of the spleen (45 per cent, $P < 0{\cdot}01$) but no inhibition of tumour-growth.

The adrenals of tumour-bearers treated with cysteinamine showed an increase of cortical lipoid as compared with untreated controls, whether the compound had been injected alone or before the *HN*2. In the dose administered, methylamine influenced neither the toxicity of *HN*2 nor its effect on tumour-growth and spleen-weight. Cortisone, which is known to increase the toxicity of X-irradiation in mice[6], likewise increased the toxicity of *HN*2 considerably.

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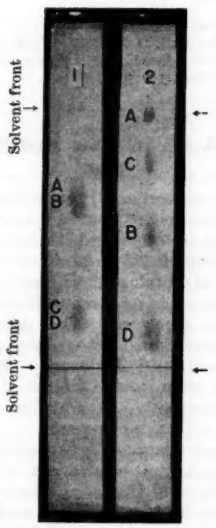
Chromatographic Separation, using Chemically Treated Paper, of Aldehydes and Ketones on the Basis of their Reactivity

WE have, for some time, been interested in the separation and identification of materials resulting from the alkaline oxidation of waste sulphite liquor. Chromatography has been used extensively for separating and identifying these materials; but until now it has not been possible to effect a complete separation of vanillin and acetovanillone on paper.

A short time ago we realized that a separation might be effected if the filter paper was modified by spraying it with a sodium bisulphite solution, since aldehydes are more reactive than ketones with bisulphite and the distribution coefficient of an aldehyde would thus be altered more than that of a ketone. The aldehyde would then tend to be more retarded on the paper than the ketone. αβ-Unsaturated ketones, in which the carbonyl activity is decreased, should scarcely be retarded at all.

We have sprayed filter paper with a dilute sodium bisulphite solution and after drying the paper have applied a mixture of vanillin, acetovanillone, veratraldehyde and acetoveratrone. These materials were also applied to an untreated paper. The papers were developed for one hour with the organic phase produced by mixing hexane (9 vol.) chloroform (1 vol.) and water (10 vol.). In the case of the untreated paper no separation of vanillin and acetovanillone or veratraldehyde and acetoveratrone was effected, although the first two compounds were separated from the latter two. On the treated paper the four materials were completely separated; the acetoveratrone had the highest R_F value followed, in order, by acetovanillone, veratraldehyde and vanillin (see accompanying illustration).

A particularly interesting feature of the use of such treated papers is the information which may be obtained regarding the functional groups in unknown



(*A*) Vanillin; (*B*) acetovanillone; (*C*) veratraldehyde; and (*D*) acetoveratrone. Paper 1, untreated; paper 2, treated with sodium bisulphite solution. Both papers were developed for one hour with hexane–chloroform–water and sprayed with 2,4-dinitrophenylhydrazine in hydrochloric acid solution

compounds. Thus, on a bisulphite-treated paper a carbonyl compound may be immediately identified as having a carbonyl activity similar to that of an aldehyde or ketone.

Following our success with aldehydes and ketones, papers treated with other chemicals were considered for the identification of different functional groups in compounds. It is a well-known fact that buffered papers have been used for the separation of acids or bases[1-4]. Such papers also provide a convenient and rapid method for distinguishing between non-acids, phenols and stronger acids. For example, using a paper treated with sodium carbonate (and the hexane solvent mentioned above), vanillin, which is a phenol and therefore acidic, remains on the starting line of the chromatogram and is distinguished from veratraldehyde which is non-acidic and moves down the paper. Also, by the use of paper treated with a solution of disodium hydrogen phosphate, vanillic acid, a carboxylic acid, remains on the starting line of the chromatogram and is distinguished from vanillin, which is phenolic and moves down the paper.

In all cases it is important to use a sufficiently active solvent for development of the chromatogram, since no conclusions concerning the chemical constitution of a material can be drawn from treated paper if the substance does not move on untreated paper. Thus, for the chromatogram with vanillic acid mentioned above, it was necessary to use water-saturated benzene as solvent.

Preliminary work using bisulphite-treated papers indicates that the method may prove useful in the field of sugar chemistry.

We wish to thank the Research Council of Ontario and the Howard Smith Paper Company for permission to publish this work.

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May 21.

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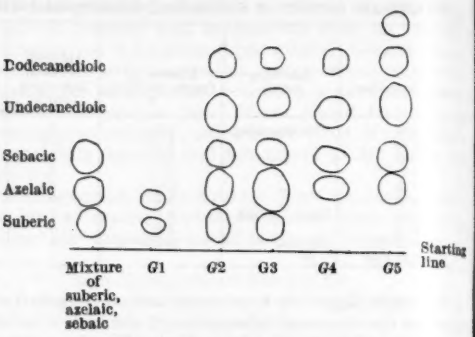
Iso-Oleic Acids in Cow and Buffalo Milk Fat

Phatak, Mahadevan and Patwardhan[1] have demonstrated the presence of four geometrical isomers of oleic acid in the *iso*-oleic acids fraction obtained from gradually hydrogenated groundnut oil. They used the method of Hilditch and Vidyarthi[2] for the oxidation of *iso*-oleic acids and separation of dibasic acids formed in the reaction. The dibasic acids were identified by paper chromatography according to the method of Reid and Lederer[3]. Four C_{18} monoethenoid acids with double bonds at Δ^{-8}, Δ^{-10}, Δ^{-11} and Δ^{-12}, respectively, in addition to elaidic acid, were thus shown to be present.

Partially hydrogenated groundnut oil is widely used in India as an adulterant of ghee (clarified butter). As the only C_{18}-monoethenoid acids present in butter so far known are oleic and vaccenic acids, it was felt that it should be possible to detect adulteration with hydrogenated oil by paper chromatography of the dibasic acids obtained on oxidation of the suspected product.



Chromatogram of dibasic acid fractions obtained by oxidation of solid fatty-acids from cow ghee

As a first step, ghee prepared from genuine cow milk fat was submitted to permanganate oxidation and separation of dibasic acid fraction according to the method of Hilditch and Vidyarthi[2]. The dibasic acids were then subjected to paper chromatography as described earlier. To our surprise, we found spots for suberic, azelaic, sebacic, undecanedioic and dodecanedioic acids on the paper chromatogram. Duplicate experiments with other samples confirmed these findings both in cow and buffalo butter fat. In a typical experiment with samples obtained from the Indian Dairy Research Institute, Bangalore, 330 gm. butter fat was saponified and the total fatty acids subjected to the lead–salt separation method as described by Hilditch. The solid fatty acids from the insoluble lead salts (158 gm.) were converted into their methyl esters. The acetone permanganate oxidation of the latter and the resolution of the products gave 4·1 gm. of dicarboxylic acids. These were converted into methyl esters and separated into five fractions by fractional distillation in vacuum. Ammonium salts of the free acids obtained on hydrolysis of the fractions were subjected to paper chromatography. The accompanying figure illustrates a tracing of spots obtained with these fractions; spots obtained by applying solutions of ammonium salt of pure dibasic acids are also included. The chromatogram for fraction *G*-5 gives an additional faint spot higher than the rest.

According to Begeman *et al.*[4], there exists a possibility of secondary production of other dicarboxylic acids during permanganate oxidation in acetone solution. They find that with the use of acetic acid as solvent the amount of these by-products is much reduced. In view of this, another sample of butter fat was submitted to permanganate oxidation as described above, but in glacial acetic acid solution. On separation of the dibasic acids fraction and chromatography, spots identical with those shown in the figure were obtained.

The chromatographic identification of the five dibasic acids leads to the conclusion that, in addition to oleic acid, other octadecanoic acids with double bonds at Δ^{-8}, Δ^{-10}, Δ^{-11} and Δ^{-12} exist in cow and buffalo butter fat. Of these, vaccenic acid, which on oxidation would yield undecanedioic acid, was already known to occur in cow butter fat[5]. The other dibasic acids identified on the chromatogram are not likely to be derived from C_{10-18} monoethenoid or C_{18} diethenoid acids in butter fat, for it has been shown that all of them, on oxidation, yield only azelaic acid[6]. Whether they can be so derived from

C_{19-22} unsaturated acids, the presence of which in butter fat has been demonstrated by Shorland and Johannesson[7], is not quite certain. The available evidence would, however, point to the positional isomers of oleic acid being the possible source of the dibasic acids identified in this investigation.

Further details of this work, which was supported by a grant from the Council of Scientific and Industrial Research, New Delhi, and the significance of our findings, will be described elsewhere. We are indebted to Mr. G. Ford, of the Hindustan Vanaspati Manufacturing Co., Ltd., Bombay, for the gift of pure dibasic acids.

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Utilization of Purines for Nucleic Acid Synthesis in Man

The utilization of purines by various species ranges from a utilization of adenine for the synthesis of both polynucleotide adenine and guanine and the utilization of guanine for polynucleotide guanine synthesis only[1], to the utilization of guanine for both polynucleotide adenine and guanine synthesis and the utilization of adenine for polynucleotide adenine only[2]. Between these contrasting patterns there exists a range of qualitative differences among various species[3].

These differences in the purine metabolism pattern of varying species made it desirable to obtain information on the utilization of purines in man and, if possible, to determine patterns of purine utilization by different cell types. This communication is an account of *in vitro* and *in vivo* studies made for this purpose.

Leucocytes, from patients with acute myeloid leukæmia, separated from red cells by the use of 'Dextran', were incubated in homologous plasma in siliconed flasks at 37° C. with carbon-14 labelled purines for four hours. Standard procedures were used for separating ribose nucleic acid and deoxyribose nucleic acid from the cells and for isolating and determining the radioactivity of individual purines. It was found that adenine-8-carbon-14 was incorporated into ribose nucleic acid adenine and transformed into deoxyribose nucleic acid guanine but not into the purines of the deoxyribose nucleic acid. The ribose nucleic acid adenine and guanine isolated from the leucocytes of one patient had a specific activity relative to the proffered labelled adenine of 15 and 5 per cent, respectively. The relative specific activities of ribose nucleic acid adenine obtained with leucocytes from two other patients were 10 and 2 per cent.

Leucocytes from another patient with acute leukæmia were incubated in separate experiments with adenine-8-carbon-14 for one, two, three and four hours, with guanine-8-carbon-14 for four hours and with 2,6-diaminopurine-2-carbon-14 for four hours. Adenine was utilized for the synthesis of ribose nucleic acid adenine and lack of aeration diminished this utilization; guanine and 2,6-diaminopurine were incorporated equally efficiently into ribose nucleic acid guanine. After four hours the activity of the nucleic acid purines was approximately 2 per cent of the activity of the purines added to the medium; at this time there was a suggestion that transformation into the other nucleic acid purine had occurred, that is, adenine was converted into ribose nucleic acid guanine, and guanine and 2,6-diaminopurine were converted into ribose nucleic acid adenine.

Adenine-8-carbon-14 (200 μC.) was given intravenously to a patient with chronic lymphatic leukæmia. Ribose nucleic acid and deoxyribose nucleic acid were isolated from leucocytes collected at intervals following the injection. It was found that adenine was incorporated into polynucleotides as ribose nucleic acid adenine and to a smaller extent as deoxyribose nucleic acid adenine, and that there was an appreciable transformation of the adenine into ribose nucleic acid and deoxyribose nucleic acid guanine. Activity of the ribose nucleic acid appeared to reach a maximum at day 5 (with an activity 710 counts/min./μM., or 0·7 per cent of the activity of the material administered) and in the deoxyribose nucleic acid at day 7 (with an activity of 130 counts/min./μM.). Full details of these studies will be published elsewhere.

I wish to thank Drs. C. Chester Stock and George Bosworth Brown for their encouragement and advice, Dr. M. E. Balis for supplying carbon-14 adenine and guanine, and the Chemotherapy Service, Memorial Center, for their co-operation. This investigation was aided by a grant from the National Cancer Institute of the United States Public Health Service.

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July 29.

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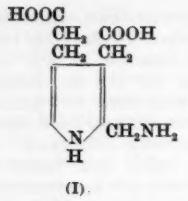
Structure of Porphobilinogen

We recently described a number of reactions of porphobilinogen, from which we concluded that it has the structure (I); but it was not then possible to eliminate the alternative structure in which the positions of the two β-substituents are reversed[1].

Dehydration of porphobilinogen by acetic anhydride and pyridine gave a lactam which was represented by (II) or possibly (III). This ambiguity has now been resolved by cyclization of the lactam to the ketone (IV) by means of polyphosphoric acid, thus proving that our formulation (I) of porphobilinogen is correct.

The tricyclic ketone (IV) crystallized from water in prisms which began to decompose above 330° without melting (found: C, 63·35; H, 5·4; N, 14·7. $C_{10}H_{10}O_2N_2$ requires C, 63·2; H, 5·3; N, 14·7 per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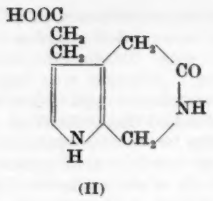
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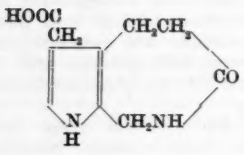
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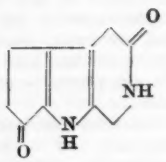
(IV)

cent). Its absorption maximum in the ultra-violet (284 mμ, ε 20,600 in ethanol) is at a shorter wavelength than that of an α-acetyltrialkylpyrrole—an effect which is also observed in model pyrroles containing a 5-membered cyclic ketone. The infra-red spectrum of the keto-amide supports the structure (IV), although it would not have by itself provided conclusive proof, owing to strong hydrogen bonding and to partial overlap of the two carbonyl stretching frequencies.

This work forms part of a programme under the general direction of Prof. C. Rimington, whose interest and advice are gratefully acknowledged. We will report our results in full in the near future.

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The 'Protactinyl' Ion

A very simple technique has been described by J. D. H. Strickland[1] for determining the charge of an ion in aqueous solution, which is applicable to radioactive tracer concentrations. The method involves competition for sites on mono-functional ion-exchange resins between the ion in question and varying amounts, in very large excess, of another ion of known charge.

This technique has been applied to the determination of the charge of the protactinium ion in dilute perchloric acid solution using trace amounts of protactinium-233. Dilute solutions of perchloric acid were prepared in the range of 0·1–3 *M*. About a million disintegrations per minute of protactinium-233 and 0·1 gm. 'Amberlite' *IR* 120 (hydrogen form) cation resin were added to 5 ml. volumes of acid in stoppered tubes. The mixtures were mechanically shaken for about two hours and then centrifuged to separate the resin 'fines'. Aliquots of the stock protactinium solution and of the perchloric acid solutions at equilibrium were taken for protactinium assay. The protactinium on the resin was obtained by difference. A plot of the ratio of the protactinium in solution to that on the resin at equilibrium against the acidity on double logarithmic paper gave a straight line of approximately unit slope. Therefore, the charge on the protactinium ion in dilute perchloric acid is + 1.

If protactinium is a member of a second rare-earth series, the actinides[2], its pentavalent ion should be similar to those of other members of this group—for example, UO_2^+, NpO_2^+ (ref. 3) and PuO_2^+ (ref. 4). As a charge of + 1 has now been found for protactinium, it seems probable that the ion present is PaO_2^+ and not PaO^{3+}, as it should be by analogy with vanadium and niobium in the same periodic group. Since a hexavalent state of protactinium is most unlikely, as the stable rare-gas electronic structure of radon would have to be opened up, it is safe to call this ion 'protactinyl' to distinguish it from protactinium 'penta' and 'tetra' compounds.

Full details of this work will be published later together with the work, at present in progress, for determining the range of hydrogen-ion concentration over which this ion is stable. Thanks are due to the Chief Scientist, Ministry of Supply, for permission to publish this note.

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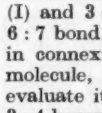
Bond-Orders in Aromatic Compounds

The most satisfactory measure of the 'character' of a bond in an aromatic compound is probably given by its 'bond-order'[1]. Although this is a theoretical quantity, its significance is demonstrated by its relationship to bond-length[1] and to other bond properties which can be measured experimentally. It has also been shown[2,3] that there is a smooth-curve relationship between bond-orders and the 'corrected'[4] redox potentials of the corresponding *o*-quinones. As redox potentials can be measured fairly readily, this relationship offers a method whereby certain bond-orders can be evaluated experimentally.

The method has now been examined with pyrene (I) and 3 : 4-benzpyrene (II). The character of the 6 : 7 bond in 3 : 4-benzpyrene may be of importance in connexion with the carcinogenic activity of the molecule, and it therefore seemed of interest to evaluate its bond-order from the redox potential of 3 : 4-benzpyrene-6 : 7-quinone[5]. At the same time, the bond-order of the 1 : 2 bond in pyrene has been evaluated from the redox potential of pyrene-1 : 2-quinone[6].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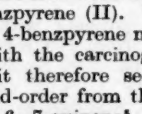
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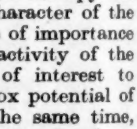
(III)

The experimentally observed redox potentials were 'corrected' in the usual way[4], and the results are summarized in the accompanying table. Redox potentials for phenanthra-9 : 10-quinone and for

1 : 2-benzanthra-3 : 4-quinone were also determined, and the results are in excellent agreement with the values given in the literature[4,7].

For the 1 : 2 bond of pyrene, the bond-order derived from the bond-order – redox potential relationship is estimated to be 1·766, in good agreement with the value (1·777) calculated by the method of molecular orbitals[8]. Similarly, the bond-order of the 6 : 7 bond in 3 : 4-benzpyrene is estimated to be 1·778.

It is not possible to evaluate bond-orders in substituted aromatic compounds in this way, but the redox potential of 9-methyl-1 : 2-benzanthra-3 : 4-quinone indicates that the 3 : 4 bond in 9-methyl-1 : 2-benzanthracene (III) must have a greater charge than in 1 : 2-benzanthracene itself, in agreement with theoretical predictions[9].

Quinone	Redox potential			
	Observed in 75 per cent alcohol	Estimated for 95 per cent alcohol	Corrected (this work)	Corrected (literature values)
Phenanthra-9 : 10-quinone	0·462	0·466	0·416	0·410
1 : 2-Benzanthra-3 : 4-quinone	0·426	0·430	0·380	0·380
9-Methyl-1 : 2-benzanthra-3 : 4-quinone	0·406	0·410	0·360	—
Pyrene-1 : 2-quinone	0·470	0·474	0·424	—
3 : 4-Benzpyrene-6 : 7-quinone	0·437	0·441	0·391	—

The potentials were determined by a polarographic procedure developed by one of us[10]. The quinone was dissolved in a buffer 0·1 *M* in sodium acetate and 0·1 *M* in acetic acid in a solvent (approximately 75 per cent alcohol) consisting of three parts of 95 per cent alcohol and one part of water. The polarogram was obtained with the dropping mercury electrode as cathode and the saturated calomel electrode as reference anode. The difference between the applied e.m.f. at the half-wave point and the e.m.f. of a cell consisting of the hydrogen electrode in the buffer alone versus the calomel electrode gave the standard redox potential of the system. The justification of this procedure has recently been given independently by Coulson and Crowell[11].

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Spectrophotometric Determination of Amino-Groups

The coupling of proteins with diazonium compounds has been studied extensively and has important applications in immunology and other fields; but the attention of investigators of the coupling mechanism has tended to be diverted from the role of the amino- and imino-groups by the brilliant red and orange-red colours produced by histidine and tyrosine, free or in peptide linkage. Busch, Patrascanu and Weber[1] have, however, isolated the colourless compound formed upon reaction of glycine with benzene diazonium chloride and have postulated the structure $HOOC.CH_2.N(N = N.C_6H_5)_2$. Eagle and Vickers[2] have shown that the amino-groups of several other amino-acids and the imino-groups of proline and hydroxyproline react with *p*-diazobenzene sulphonic acid.

We have studied by spectrophotometric methods the reaction of diazotized sulphanilic acid with glycine, lysine, arginine and tryptophane. The compounds formed by glycine and lysine are characterized by absorption maxima at 363 mμ, and their extinction coefficients are of the same order as those shown by the azo derivatives of histidine and tyrosine[3]. The solutions are yellow, but the azo-amino compounds cannot be determined directly by colorimetric methods.

The usual initial procedure was to form the diazonium salt in acid solution by adding 1 ml. of 1 per cent solution of anhydrous sulphanilic acid in 10 per cent hydrochloric acid and 1 ml. of 5 per cent sodium nitrite solution to a 25 ml. flask containing an aliquot of the amino-acid solution not exceeding 10 ml., and after 30 minutes at room temperature to add 3 ml. of 20 per cent sodium carbonate solution and make up to volume with water.

The kinetics of the reactions of the amino-group are influenced by the *p*H attained, the optimum for lysine being at *c.* *p*H 9. The reactions are slower than the virtually 'instantaneous' coupling of histidine and tyrosine (which can, however, be analysed by indirect methods[4]), and the period elapsing between adding the alkali and diluting for measurement of the extinction was standardized at 30 minutes. The presence of ethanol in the system as in the method for histidine[5] reduces the extinctions considerably, and should be avoided. To minimize deamination the mixture of sulphanilic acid and nitrous acid can be diluted to about 10 ml. initially and the amino-acid solution added just before the alkali.

The extinctions at 363 mμ for the azo-derivatives of glycine and lysine both conform to Beer's law when referred to the initial amino-acid concentrations. The molecular extinction coefficient for the compound presumed to be *bis* (azobenzene sulphonic acid) glycine is *c.* 30,000. The lysine derivative gives similar values and the extinction remains constant when the initial molar ratio of lysine to sulphanilic acid exceeds $\frac{1}{2}$, suggesting that the ε-amino-group does not participate in the reaction. In the spectrum for the arginine derivative, the absorption maximum is displaced to 356 mμ and the extinction coefficient is lower than for glycine or lysine. The absorption spectra for the azo derivatives of histidine and tyrosine show only the bands characteristic of the ring azo derivatives[3], indicating that the diazonium salt reacts preferentially with the imidazole and phenolic groups of these amino-acids. Tryptophane[2] is reported to react at both the indole and amino-groups: our

absorption curves support the view that the amino-group reacts, but only to a small extent.

The absorption spectra of the azo-derivatives of various intact proteins (casein, paracasein, α-casein, gelatin, pepsin, fibroin) and their acid hydrolysates have been examined. The extinctions at 363 mμ were found to increase with amino-nitrogen. A considerable amount of useful information about the constitution of a protein and the accessibility of its coupling groups can be obtained from a single absorption spectrum of this type, which is very much more sensitive than the ordinary ultra-violet absorption curve.

In applying the reaction to the determination of amino-groups in proteins and their degradation products, the main difficulty involves assessing the contribution of the imidazole, phenolic and imino-groups to the absorption at 363 mμ. However, in various possible applications of a comparative nature, such as following the course of hydrolysis, deamination, the action of a proteolytic enzyme or of peptide synthesis, such interference may not be relevant. The principal advantage appears to lie in the simplicity and rapidity with which the determinations can be made. The high values given by glycine in the Van Slyke manometric method of determining amino-nitrogen and the uncertainties in the interpretation of formol titrations emphasize the desirability of developing other methods of determining free amino-groups. A full account of these studies will be published elsewhere.

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May 7.

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Half-value Periods for the Decay of Aluminium-26, Aluminium-25 and Nitrogen-13

The decay of the positron-emitters aluminium-26, aluminium-25 and nitrogen-13 was measured using a nine-channel scaler, which recorded the counts received from a Geiger–Müller tube in nine successive equal periods. These periods were 2 sec. each for the two aluminium isotopes and 200 sec. each for the nitrogen isotope. The isotopes were produced by resonant capture of protons by magnesium-25, magnesium-24 and carbon-12, respectively. The proton beam was switched off when counting began, and the switching from one channel to the next was done by an electronic timer, accurate to one part in a thousand.

The half-value periods were calculated from these results using the rigorous treatment given by Peierls[1] and were as follows: aluminium-26, $6{\cdot}68 \pm 0{\cdot}11$ sec.; aluminium-25, $7{\cdot}62 \pm 0{\cdot}13$ sec.; and nitrogen-13, $602{\cdot}9 \pm 1{\cdot}9$ sec. The half-life measurement for nitrogen-13 is in fair agreement with those of $10{\cdot}2 \pm 0{\cdot}1$ min. and 10·1 min. obtained by Cook *et al.*[2] and Siegbahn and Slätis[3], respectively. Earlier published measurements ranging from 9·93 to 11·0 min. have been listed by Ward[4].

There has been some confusion previously in the measurement of the half-value periods of aluminium-26 and -25, due to the use of unseparated magnesium targets[5] and the fact that the two half-lives are of comparable value. In the present work separated magnesium-25 and -24 targets were used. The magnesium-24 targets were bombarded with protons of energy 418 keV. and the magnesium-25 targets with protons of energy 392 keV. Protons of these energies had previously been found to produce resonances on magnesium-24 and -25 isotopes respectively. It was also found that the yields from magnesium-24 for 392-keV. protons, and of magnesium-25 for 418-keV. protons, were each negligible.

Bradner and Gow[6] have observed half-lives of 6·3 and 7·3 sec. after bombarding separated magnesium-26 and -25 targets respectively with high-energy protons from a linear accelerator. These half-lives are ascribed to aluminium-26 and -25 produced by (p,n) reactions at this high energy, and are in each case somewhat lower than those obtained in the present work. The half-life of aluminium-26 has also been determined by Perlman and Friedlander[7], who obtained a value of 7·0 sec., and Allan and Wilkinson[8], who obtained a value of $7{\cdot}0 \pm 0{\cdot}2$ sec. Wäffler and Hirzel[9] obtained a value of 7·2 sec. and Katz and Cameron[10] one of $6{\cdot}5 \pm 0{\cdot}1$ sec.

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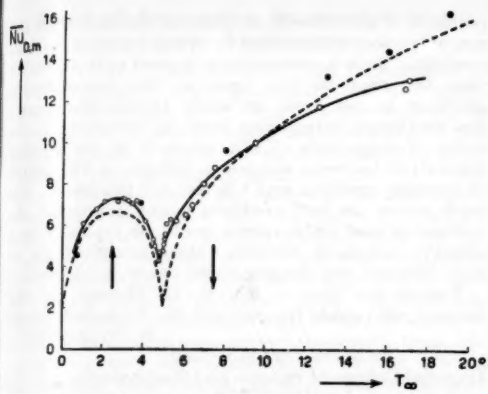
Heat Transfer from Water to Ice by Thermal Convection

Heat transfer may be described by the coefficient α occurring in Newton's law of cooling, the other factors being the surface and the temperature difference. For bodies determined by one dimension, for example, a sphere of diameter D in an infinite fluid of conductivity λ, it is better to use the dimensionless Nusselt number $Nu = \alpha D/\lambda$.

By submerging a sphere of ice in water of temperature $T\infty$ (° C.) and studying the gradual decrease of its diameter or its change of weight in the course of time, we have found the experimental points, as shown in the graph. As the phenomenon is evidently related to the anomalous expansion of water, we take the coefficient of expansion to be a linear function of temperature $\beta = p + 2qT$, with $p = -64{\cdot}3 \times 10^{-6}$, $q = +8{\cdot}51 \times 10^{-6}$, and T being measured in deg. C. For the sake of brevity, we here omit a number of



Convective heat transfer water–ice, showing a minimum due to inversion of the convection current at 4·8° C. O—O—, from observed diameter; ●—●—, from observed weight; – – – –, theoretical curve

minor refinements: the introduction of a term with T^2 in β, the influence of the excess liquid originating from the melting process, and the temperature dependence of Prandtl's number, *Pr* (the ratio of the kinematical viscosity ν to the heat diffusivity *a* of water).

The heat convection would normally be described by a law,

$$Nu = 0{\cdot}6\,(Pr.Gr)^{1/4},$$

the Grashof number *Gr* being given by $\beta g T_\infty D^3/\nu^2$. Because of the temperature dependence of β, we had, however, to recalculate the viscous flow in these circumstances, assuming in the usual way that this flow and the temperature gradient are restricted to a thin boundary layer, and applying the usual approximations to this layer. The result is that the same formulæ hold, provided we replace β in *Gr* by a more complicated expression, which reduces to

$$\beta' = p + 1{\cdot}51\,qT_\infty,$$

when the refinements are neglected. The factor 1·51 expresses the way in which the 'effective' or 'mean' expansion coefficient over the boundary layer is intermediate between the extreme values *p* and $p + 2qT_\infty$ occurring at its two sides.

From the values given, it is easily seen that β′ is zero for $T_\infty = 5°$ C. A slightly different and probably better approximation gives 4·8° C. At this temperature of the water a minimum of the heat transfer number *Nu* is to be expected, in good agreement with our experimental results. The value of the minimum is, of course, not really zero, as the resulting stagnation is irreconcilable with our assumption of a boundary layer. Indeed, the value of *Nu* could never fall below 2, the value for pure conduction by a stationary infinite fluid.

The direction of motion of the water in the boundary layer is opposite at the two sides of the inversion temperature 4·8° C., as indicated by the arrows in the accompanying figure. This has also been verified experimentally. A full account is to appear elsewhere[1].

Codegone[2] has observed a kindred phenomenon in water of temperature T_∞ accommodating itself to a hotter surrounding. His minimum occurs at $T_\infty = 4°$ as a consequence of the fact that only infinitesimal temperature differences occur in the water of his experiments, the outer wall of his vessel being heavily insulated. Another case of 'convective inversion' has been found by Powell[3] for humid air in contact with a wet-bulb thermometer.

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Lab. v. Techn. Physica T.H.,
Delft. June 30.

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An Interferometer for Simultaneous Observation of Concentration and Concentration Gradient in Liquid Columns

Several methods have been suggested for the observation of one-dimensional concentration and concentration gradients in liquids, a problem occurring in electrophoresis, ultracentrifuging and diffusion measurements; a bibliography has been given by H. Svensson[1]. In the methods for observing concentration directly, either Rayleigh or Fizeau interference fringes are used for plotting the optical path-length through the liquid; the methods for observing the gradient of the concentration use various modifications of the 'diagonal schlieren' system of Philpot; in all cases, complicated systems requiring a number of high-quality optical components are required.

In the method described here a simple and easily adjusted optical system plots both concentration and concentration gradient simultaneously as interference fringes superimposed on an image of the cell containing the liquid.

Referring to the plan view in Fig. 1, *S* is a monochromatic source of light near the focus *F* of a collimator *K*; *C* is a double cell containing liquid with varying concentration in one compartment (*A*) and homogeneous liquid in the other (*B*); *M* is a plane mirror, *W* a Wollaston double-image prism of doubling angle φ, and *P* a 'Polaroid' screen with its principal directions at 45° to those of *W*.

The divergent wave-front from *S* is split by *P* and *W* into two coherent plane-polarized wave-fronts; these are indicated at s_1 and s_2 after passing through *K*. Corresponding points on s_1 and s_2 are separated laterally by a distance $\delta \approx \varphi.KF$ and s_1 and s_2 are inclined to each other at an angle α which depends on the distance of *W* from *F*. The wave-fronts s_1 and s_2 return from *M* and are recombined by *W* and *P*, but corresponding rays have traversed different parts of *C* so that, on viewing from *S′* (which is the image of *S*), two horizontally separated images of *C*, 1 and 2 are seen.

The wave-fronts s_1 and s_2, being coherent, will form interference fringes which are loci on which the

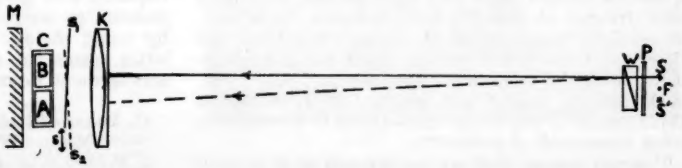

Fig. 1

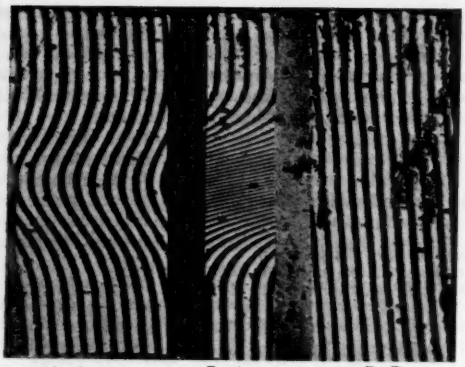

Fig. 2

difference between optical path-lengths along corresponding rays of s_1 and s_2 is constant. The arrangement of Wollaston prism and polarizer is essentially the same as that used by Lenouvel[2] as a wave-front shearing interferometer for determining the aberrations of optical instruments.

If the doubling angle φ is suitable, the two images of the cell will partly overlap. Let x and y be horizontal and vertical co-ordinates in the cell, and let $V(y)$ be the optical path through compartment A at height y; then, in the region where image A_2 overlaps image B_1, the bright fringes satisfy the equations

$$V(y) + \alpha x = \tfrac{1}{2}k\lambda, \quad (k = 0, \pm 1, \pm 2, \ldots) \qquad (1)$$

Thus the x-displacement of any fringe at height y is a linear function of the refractive index at y, so that the fringes in the A_2–B_1 region map the concentration in the cell.

If, in addition, W and P are turned through a small angle about the optical axis, the lateral separation δ between s_1 and s_2 will have a small vertical component, say, ε; then, in the region where A_1 overlaps A_2, the equations of the fringes will be

$$V(y+\varepsilon) - V(y) + \alpha x = \tfrac{1}{2}k\lambda, (k = 0, \pm 1, \pm 2, \ldots),$$

which can be written in the form

$$\alpha x = -\varepsilon \left\{ \frac{V(y+\varepsilon) - V(y)}{\varepsilon} \right\} + \tfrac{1}{2}k\lambda. \qquad (2)$$

Thus, the x-displacement of any fringe is, for a small enough value of ε, a linear function of the gradient of the refractive index, so that the fringes in the A_1–A_2 region map the concentration gradient.

In both cases the constants of the linear relations in question are easily determined; the horizontal scale of the integral and gradient patterns can be varied together by moving W and P along the axis, while the scale of the gradient pattern alone can be varied by rotating W and P.

The fringe system can be photographed by placing a camera behind S'. The photographs in Fig. 2 show fringes obtained from a diffusion boundary; the straight fringes in the B_1–B_2 region indicate the direction of the base-line from which the x-displacement should be measured. The cell used was 1 cm. thick and the wave-length was 0·5461 μ, so that a displacement of one fringe corresponds to a refractive index increment of 0·000027.

The two images of S are recombined at S' in such a way that the fringe systems formed by the different points of S all coincide, so that no restriction on the size of the source is needed to obtain maximum fringe contrast. Such a restriction is needed only to ensure that the rays do not traverse the concentration gradient at too great an angle to the horizontal; the maximum permissible angle is obviously of the order of magnitude of h/t, where h is the vertical separation between successive fringes in the region of steepest gradient and t is the cell thickness. For work where the last condition is not important, the collimator and plane mirror could be replaced by a concave spherical mirror; also, modifications to suit different cell designs could easily be devised.

Thanks are due to Mr. E. G. Menage, of this Section, who made the cell and the Wollaston prism.

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[1] *Acta Chem. Scand.*, **5**, 1410 (1951).
[2] *Rev. Optique*, **17**, 350 (1938).

Thin Metallic Films for Anti-Reflexion Coatings on Dielectric–Air Interfaces

In the course of some experiments with thin rhodium films, I noticed that the intensity of light reflected from a rhodiumized glass–air interface is much less than that reflected from the same interface when used in the air–glass sense. Sheared wave-front interferometric study of the edge of such a film indicated that this may be primarily due to a half-wave phase shift which can be seen at the glass–air boundary, but not when the same boundary is air–glass, the out-of-phase condition reducing the reflective intensity.

When the rhodium film had transmission factors exceeding 50 per cent the effect became so marked that the rhodiumized glass–air interface had reflexion factors markedly less than the uncoated portions of the same surface. By examining a continuously graduated coating it was established that the reflexion intensity is virtually zero when the transmission factor of the rhodium film is 70 per cent. This applies to glass having a refractive index about 1·52.

The reflected intensity was so low that microscopic examination of the surface by normal, bright-field vertical illumination resulted in a very striking dark-field image, dielectric particles and chemical film patches deposited on the surface appearing brightly illuminated against a black background. The chemical film patches and crystals produced interference colours markedly resembling those seen when viewing birefringent crystals in transmitted light between crossed nicols.

Although the transmitted light absorption and the uni-directional condition both impose severe limitations, the method may prove useful where all that is required is to prevent internal reflexions. It may be possible to improve the transmitted light intensity by using metals other than rhodium, though the latter seems the obvious choice for the microscope arrangement described above.

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Effect of Anomalous Attenuation in a Linear Accelerator

In a recent communication[1], the performance of a travelling-wave linear accelerator has been given. It was shown that, due to the importance of higher terms in the expansion representing the power flow in the accelerator guide, the series impedance is lower than had been previously assumed. This, of course, leads to a reduction in the energy of the accelerator. The series impedance for the guide in question (2 cm. pitch, $a/\lambda = 0{\cdot}168$ and phase velocity approximately equal to light velocity) has been determined both theoretically and experimentally, and a value of 3·5 megohms/cm.[2] obtained. From this value and experimentally determined data on the position of electron bunching, the energy expected from the accelerator may be calculated for various loading conditions. Such values are shown compared with the measured performance of the accelerator in Fig. 1, and it will be noted that, although agreement at light loading is good, serious discrepancy occurs at higher loading. The discrepancy is attributed to an anomalous attenuation which has been found to occur in the accelerator over a certain range of power flux.

Although measurements of attenuation of the three-metre length of guide and associated components indicate a value of 2·5 db. for all power-levels in the absence of magnetic focusing field, the application of such fields is found to have a considerable effect. In the presence of focusing fields the attenuation, although still of the order of 2·5 db. for power fluxes of a few milliwatts and several megawatts, exhibits a variation with power in an intermediate range. In this particular case, an attenuation greater than 12 db. has been noted for an input power of 250 kW., and as power is increased attenuation falls, approaching 2·5 db. for an input of 3 MW. The effect is apparently not dependent on the gas pressure in the guide, provided that this is reasonably low. It would therefore appear to be additional to the radio-frequency absorption by gas noted by Harvie and Mullett[2] and which has also been observed in the present equipment.

At light loading the power-level in the guide is such that anomalous attenuation may be expected to have little effect. When, however, the loading is increased, the power flux is considerably reduced and anomalous attenuation may be expected to affect performance. The mechanism causing the increase in attenuation is not fully understood, and it is therefore impossible to make an accurate allowance for the effect. If, however, it is assumed that the criterion which determines the value of the anomalous attenuation is the mean of the input and output power fluxes, the calculated performance figures may then be modified. Such modified results are shown in the graph and, clearly, improvement in agreement with the measured performance is obtained at the higher loadings.

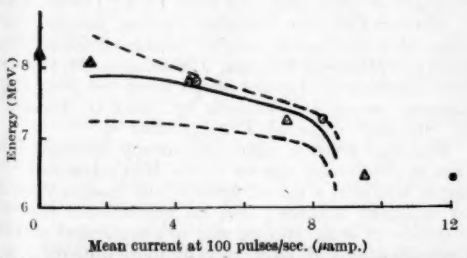

Fig. 1. Comparison of measured and calculated energies: ——, measured energy of peak of spectrum; – – –, approximate limits of spectrum. Points shown as ⊙ are calculated neglecting anomalous alternation, and △ making an allowance for anomalous attenuation

A similar increase of attenuation has been noted[3,4] in a dielectric-loaded guide by the Linear Accelerator Group at Malvern of the Atomic Energy Research Establishment, and a qualitative explanation of the effect has been suggested in terms of secondary emission and multi-pactor effect inside the corrugations of the guide.

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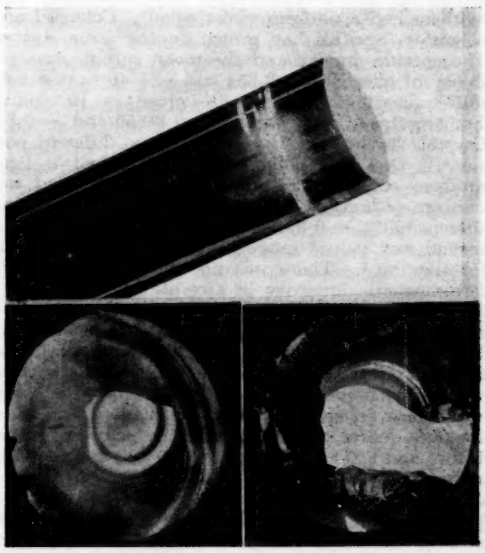
Transverse Cracks in Glass Rod

In the course of work on crack propagation in brittle fracture, we have been breaking glass rod in tension by the Bridgman[1] technique of applying radial fluid pressure. A few specimens, cut from one 9-mm. diameter 'Hysil' glass rod, contained after fracture transverse cracks which had not been propagated completely across the section, as shown in Fig. 1. The diameter and thickness of the large crack in this specimen can be estimated from the end view (Fig. 2); this was taken with mercury light, and since it shows four interference fringes the crack was about 10,000 A. thick in the centre.

(1)



(2) (3)

(1) Cracks in glass rod (×2½); (2) end view of rod (×3½)
(3) fracture surface of crack in (2) (×3½)

Although these cracks appear to be completely enclosed, most of them could be traced to the surface on one side. The cracks could be propagated across the specimen by a shock load, and the resulting fracture surface (Fig. 3) revealed the flat (white) specular region of the original crack extending on one side to the edge, surrounded by the complex array of steps and fissures of the subsequent fracture. At higher magnification, under the opaque stop microscope[2], it could be seen that the original crack started at the surface and spread progressively into the centre of the rod.

The nature of these cracks suggests that the rod contained axial internal stresses which were tensile in the core and compressive in the periphery. This stress system could well arise during cooling, and accounts for the existence of completely internal cracks and for the enclosed appearance of the remainder when the load is removed.

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April 15.

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Magnetic Study of Amethyst

Amethyst (a well-known variety of quartz) has a rich violet colour, the origin of which has been discussed by several workers. Tutton[1] states that the twinning of right-handed and left-handed quartz may be the probable cause. Holden[2] has suggested that an impurity like iron oxide imparts the colour. An inorganic dye, the physical state of aggregation of which changes on heating, has also been mentioned as another possibility. It was felt that a magnetic study of quartz and amethyst may throw some light on this problem.

Two specimens of amethyst were available. One of them had a uniform violet colour. Coloured and colourless crystals had grown on the same cluster. The specific gravity and the mean specific susceptibility of quartz were 2·654 and − 0·40 respectively (all susceptibility values are given in 10^{-6} unit). For amethyst, these values were 2·656 and − 0·33. Crystals in the other group had three different portions. One was colourless, another had a light uniform colour and the third was dark and not uniform. Samples from these portions gave mean susceptibility − 0·33 for the first, − 0·112 for the second and values ranging from + 0·20 to + 0·53 for the third. There was no evidence of any free ferromagnetic impurity in any of the specimens.

Amethyst loses its colour when it is heated to about 260° C. A few carefully chosen crystals were baked at 430° C. for about two hours. On redetermining the susceptibility, the diamagnetic value was always found to show a rise. The increased value was, however, still far below the diamagnetic value for pure quartz. In a representative case, the values before and after heating were − 0·200 and − 0·216 respectively.

These results show that the tinctorial agent is paramagnetic. The possibility of manganese is excluded, since crystals which do not show any trace of manganese are known to be highly coloured[3]. The magnetic evidence supports the view that the colour is due to ferric iron, existing as ferric hydroxide or a mixture of ferric oxide and ferric hydroxide. On heating the crystal, the stable ferrous oxide appears to be formed. The conversion of the ferric ion into the ferrous ion is accompanied by a slight diminution in the paramagnetic component.

Chemical tests showed that while moderately coloured crystals contained 0·21 per cent of ferric iron, strongly coloured specimens gave 0·31 per cent. These quantities are just of the right order of magnitude to account completely for the paramagnetism of the corresponding amethyst crystals.

The magnetic anisotropy of quartz and amethyst were studied by Krishnan's critical torsion method[4]. For two specimens of quartz, $\chi_\perp - \chi_\parallel$ (the axis of reference being the rhombohedral axis) was found to be 0·113 and 0·130. The light-coloured crystals showed an anisotropy of 0·042, whereas for strongly coloured specimens it was 0·0114. These results show that the anisotropy is reduced by the colouring matter, $\chi_\parallel$ being more influenced than $\chi_\perp$.

Details of this work will be published elsewhere.

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New Erythrean Fishes from the Mediterranean Coast of Israel

Since the opening of the Suez Canal, Erythrean fishes have penetrated to the region of the eastern Mediterranean. This penetration is still taking place and the results can be seen in : (*a*) appearance of new Erythrean species in the eastern part of the Mediterranean ; (*b*) the spreading of Erythrean species, already established in the eastern Mediterranean close to the Suez Canal, to new areas (a movement following the coast of Israel, Syria, Turkey and Rhodes) ; (*c*) the increased abundance of the invading species in areas where they were formerly scarce.

In order to follow all the changes, it is necessary to carry out frequent faunistic observations in this part of the Mediterranean. Unfortunately, the eastern Mediterranean has been little investigated from an ichthyological point of view, and in many cases the reports on the changes in fish distribution have been issued after great delay.

The fishes determined and listed here were caught between October 1951 and June 1952. The collection of the Sea Fisheries Research Station, however, contains also specimens caught during previous years, such as *Sphyraena obtusata*, *Callionymus* cf. *brunneus* (see below) and *Apogon duops* from the year 1947 ; Lissner[1] noted *Dussumieria* sp., and G. Haas and H. Steinitz[2] reported *Platycephalus* sp.

Kosswig[3] gives an extensive survey on the infiltration of Erythrean species to the Mediterranean. His paper contains a list of twenty-four species reported by different authors ; but he pointed out that the presence of some species was not confirmed and the determinations of taxonomically more difficult genera (*Caranx*, *Serranus*) might be wrong. Hence he limited the number of definitely established Erythrean species in the Mediterranean to fifteen. Haas and Steinitz[2]

listed ten Erythrean species from the Mediterranean coast of Palestine. Several of them are now very common: *Mulloides auriflamma* is caught by trawl in considerable quantities and is of commercial value; *Siganus rivulatus* and *Stephanolepis ocheticus* are among common fishes met with along the shores; *Hepsetia pinguis* is the most abundant among Atherine fishes of this coast.

To the list of Red Sea fishes already mentioned from the Mediterranean but not previously reported from the Israel coast should be added: (1) *Tetrodon spadiceus* (Rich.); (2) *Upeneus* sp.

Besides these fishes, eight Indo-Pacific species were also determined, which so far as it is known have not yet been reported from the Mediterranean. Part of them, however (the first four in the list below), have been observed in the Suez Canal[4-7]. These fish, found along the Israel coast-line, have been identified as follows: (1) *Dussumieria prouctissima* Chab., common along the shores and often caught by trawl and purse seine; (2) *Sphyraena obtusata* C.V., caught in considerable quantities by trawl and ring net; (3) *Caranx djeddaba* (Forsk.), kindly determined by J. T. Nichols of the American Museum of Natural History; (4) *Apogon thurstoni* Day, appears often in Haifa Bay; (5) *Istiophorus gladius* (Brouss.), a young specimen 356 mm. in total length; (6) *Callionymus* cf. *brunneus* Fowler, common bottom-fish along the shores. The addition of 'cf.' indicates some systematical deviation from Fowler's description; (7) *Saurida grandisquamis* Gthr., caught occasionally in Haifa Bay during winter months; (8) *Platycephalus indicus* (L.), rare.

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Aug. 7 (1952).

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Measurement of Colonization and Survival of Soil *Fusaria* in Detached Plant Tissue

The colonization in soil of detached host tissue by soil-inhabiting parasitic fungi was demonstrated by Sadasivan[1] with *Fusarium culmorum*. Recently, this technique has been utilized by several University of Madras research workers in studies to determine the effect of micro-elements on the colonization and survival of *Fusaria* in cotton and gram (*Cajanus cajan*) roots[2-4]. Generally, they found that zinc, aluminium, boron, lithium, manganese and cobalt at soil concentrations from 100 to 400 p.p.m. retarded *Fusarium* colonization and survival.

Investigations on flood-fallowing for the eradication of *F. oxysporum* f. *cubense* are seeking to determine some of the factors involved in the survival or non-survival of this fungus in both submerged and non-submerged soils[5,6]. The root-colonization technique is a valuable tool in these studies although quantitatively this method is not sufficiently accurate. Previously, quantitative data have been obtained by culturing on agar approximately 25 root pieces per treatment to determine percentage colonized, that is, yielding *Fusarium* colonies, or similarly, percentage fungus survival in previously colonized roots subjected to treatment[7].

In the case of fleshy roots, such as bananas, decay is rapid and in a period of 2–3 months only the tubular parchment-like periderm and woody stele remain. Culturing of these decayed root pieces to determine percentage colonization or survival gives erratic results even when large numbers are used. This lack of consistency is attributed in part to the rapid development of bacteria and saprophytic fungi on the agar plates. Some of the fungi, which are rapidly growing spreaders, have been observed to inhibit or obscure developing *Fusarium* colonies. Also, the extent of colonization cannot be accurately determined unless numerous small pieces of the root are cultured separately.

In studies on the effect of soil moisture on *Fusarium* survival in colonized banana roots, it was observed that this fungus developed rapidly and abundantly on agar plates after decayed colonized roots were finely cut in a Waring blendor and diluted with water[6]. The Waring blendor–dilution technique was developed further[8] and recent unpublished data indicate it to be amenable to an improved quantitative analysis of *Fusarium* growth and survival in colonized roots. Fragmentation of mycelium using this technique results in a much higher colony count than would be obtained by other methods. Thus, this method is particularly valuable in determining minute areas of survival that are rapidly overgrown and inhibited from development on culture media by soil saprophytes including other *Fusarium* spp. Of course, mycelial fragmentation tends to indicate a higher level of survival than may actually exist. Nevertheless, in diseases such as the *Fusarium* wilts, any level of fungus survival indicated is of value in predicting the subsequent behaviour of susceptible or partially resistant varieties.

The Waring blendor–dilution technique is being used in studies to determine the effect of various compounds on colonization and survival of soil *Fusaria* in detached plant tissue. Using this method of measuring colonization and survival of *F. oxysporum* f. *cubense* in banana roots, the micro-elements zinc, boron and manganese at concentrations of 100 and 200 p.p.m. have exerted no significant effect. Survival in colonized roots has occurred even under treatments that eradicated the fungus from the surrounding soil. These treatments included submerging the soil and roots for three months under two inches of water with and without sodium nitrate, and saturating the soil with aqueous solutions containing 400 p.p.m. of various fungicides. Thus far, cyanamid at 2,500 lb. per acre and 1 per cent formaldehyde drench have been effective in drastically reducing *Fusarium* survival in colonized roots in the laboratory.

A detailed report of these studies will be made elsewhere.

R. H. Stover

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May 30.

[1] Sadasivan, T. S., *Ann. App. Biol.*, **26**, 497 (1939).
[2] Sarojini, T. S., *J. Madras Univ.*, **19**, 1 (1950).
[3] Sarojini, T. S., *Proc. Ind. Acad. Sci.*, Sec. B, **33**, 49 (1951).
[4] Sulochana, C. B., *Proc. Ind. Acad. Sci.*, Sec. B, **19**, 209, **229**, 234 (1952).
[5] Stover, R. H., Thornton, N. C., and Dunlap, V. C., *Soil Sci.* (in the press).
[6] Stover, R. H., *Phytopath.* (in the press).
[7] Subramanian, C. V., *J. Ind. Bot. Soc.*, **26**, 209 (1946).
[8] Stover, R. H., and Waite, B. H., *Phytopath.* (in the press).

FORTHCOMING EVENTS

Monday, September 7—Friday, September 11

INSTITUTION OF CHEMICAL ENGINEERS and CHEMICAL ENGINEERING GROUP (SOCIETY OF CHEMICAL INDUSTRY) (at Olympia, London, W.14).—Chemical Engineering Conference.

Tuesday, September 8—Thursday, September 10

FARADAY SOCIETY (in the Department of Chemistry, Leeds University, Leeds).—General Discussion on Dyeing and Tanning.

Wednesday, September 9

INSTITUTE OF PETROLEUM (at Manson House, 26 Portland Place, London, W.1), at 5.30 p.m.—Mr. F. W. B. Porter: "Autofining".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER IN AGRICULTURAL CHEMISTRY at the University College of the Gold Coast—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (September 10).

LECTURER IN GENETICS in the Department of Botany at the University College of the Gold Coast—Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (September 10).

SENIOR ASSISTANT ENGINEER (with honours degree in electrical or mechanical engineering, and preferably with research experience on steam turbine plant) at the British Electricity Authority Research Laboratories, Leatherhead, to carry out testing, development and research work in connexion with electricity generation—The Director of Establishments, British Electricity Authority, Winsley Street, London, W.1, quoting N/412 (September 12).

ELECTRICAL ENGINEER (with degree or diploma in electrical engineering or equivalent qualification, and preferably with experience of light electrical engineering, including electronics) at the Technical and Scientific Register—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D.334/53A (September 14).

LECTURER (with honours degree in botany, zoology or horticulture) IN THE DEPARTMENT OF BIOLOGY—The Principal, Wigan and District Mining and Technical College, Wigan (September 14).

RESEARCH ASSISTANT IN THE DEPARTMENT OF GEOGRAPHY—The Secretary, University College, Gower Street, London, W.C.1 (September 19).

SENIOR AND JUNIOR RESEARCH FELLOW IN ANTHROPOLOGY, and a SENIOR RESEARCH FELLOW IN PSYCHOLOGY in the East African Institute of Social Research, Makerere College—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (September 19).

ASSISTANT LECTURER IN PHILOSOPHY—The Secretary, The University, Belfast (September 21).

SENIOR LECTURER IN CHEMISTRY and a LECTURER IN SCIENCE at Fourah Bay College, Sierra Leone—The Secretary, Advisory Committee on Colonial Colleges, 15 Victoria Street, London, S.W.1 (September 21).

DIRECTOR (with experience in timber technology, and in the utilization of tropical timbers) OF A FOREST PRODUCTS RESEARCH LABORATORY in Burma, to plan and develop the laboratory as regards buildings, equipment and organization—The Burmese Embassy, 19A Charles Street, London, W.1 (September 22).

ASSISTANT LECTURER (with honours degree in agricultural chemistry or chemistry) IN AGRICULTURAL CHEMISTRY (Dairy Chemistry)—The Registrar, The University, Reading (September 26).

RESEARCH OFFICER (with university honours degree with physics as a major subject or equivalent qualification) IN THE DIVISION OF METROLOGY, Commonwealth Scientific and Industrial Research Organization, Chippendale, N.S.W., Australia, to carry out research in interferometry (optical and microwave) with particular reference to the measurement of length and associated quantities—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting 750/82 (September 26).

MCROBERT RESEARCH FELLOWSHIP to undertake research relating to any disease that is generally regarded as malignant or incurable in any one of the following fields selected by the candidate and approved by the University: Bacteriology, Biology, Chemistry, Chemotherapy, Clinical Science, Endocrinology, Pathology or Physics—The Secretary, The University, Aberdeen (September 30).

RESEARCH ASSISTANT IN METALLURGY—The Registrar, University, Manchester 13 (October 1).

CHAIR OF EDUCATION in the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (October 15).

ASSISTANT LECTURER, Grade "B", IN MATHEMATICS, at the Wolverhampton and Staffordshire Technical College—Clerk to the Joint Education Committee, Education Offices, North Street, Wolverhampton.

CHEMIST-ASSAYER (with honours degree in chemistry and (*a*) Certificate from University of having reached a good standard in practical inorganic chemistry and a two-year course of postgraduate training at the Imperial College of Science and Technology; or (*b*) at least two years postgraduate experience in silicate analysis and assaying) in the Gold Coast—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.105/13/06.

ELECTRICAL ENGINEERS, (*a*) Scientific Officer class (with first- or second-class honours degree in electrical engineering or equivalent) or (*b*) Experimental Officer class (with H.S.C., science, or equivalent) at Ministry of Supply Experimental Establishments at Malvern, Farnborough and Sevenoaks, for research, development or design in telecommunications, radar, electronics, instrumentation or light electrical measurements—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D.232/53A.

ENGINEER (A.M.I.C.E., E.E. or M.E., or with exempting qualifications) with the Ministry of Supply, Hayes, to control inspection of all types of electronic equipment—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D.327/53A.

ENGINEERS (A.M.I.Mech.E. or A.M.I.E.E., or equivalent) or PHYSICISTS (with honours degree in physical or chemical engineering and/or A.Inst.P., A.M.I.Chem.E., or equivalent) in the Division of Atomic Energy (Production), at Risley and Capenhurst, to undertake the design, adaptation and development of (*a*) instruments, including electro-chemical types for measurement of temperatures, pressures, *p*H flow and radioactivity, and (*b*) equipment for analysing gases and liquids—Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs, quoting 492.

PROFESSOR OF GEOGRAPHY—Dr. A. A. Duri, Dean, College of Arts and Science, Baghdad, Iraq.

RESEARCH FELLOWS IN GEOPHYSICS, including petrology and crystal and high pressure physics—The Registrar, Australian National University, Box 4, G.P.O., Canberra, A.C.T., Australia.

SUPERVISORS (with a diploma or degree from a recognized school of metalliferous mining, and at least five years experience of alluvial prospecting) IN THE MINES DEPARTMENT, Nigeria—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.99/14/04.

TIMBER RESEARCH OFFICER (with honours degree in engineering) IN THE DEPARTMENT OF FORESTRY, Federation of Malaya, to take charge of new timber research laboratory at Kepong, where investigations are carried out on Malayan timbers—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.61/60/01.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

The British Coal Utilisation Research Association. Annual Report 1952. Pp. 56. (Leatherhead: British Coal Utilisation Research Association, 1953.) 7*s.* 6*d.* [17

International Tin Research Council. Report of the Tin Research Institute, 1952. Pp. 16. (Greenford: Tin Research Institute, 1953.) [27

Institute of Personnel Management. Occasional Papers No. 2: Some Problems of a Factory: an Analysis of Industrial Institutions. By Wilfred Brown. Pp. 20. (London: Institute of Personnel Management.) 3*s.* [27

Department of Scientific and Industrial Research and Fire Offices' Committee. Report of the Fire Research Board, with the Report of the Director of Fire Research for the Year 1952, and a Survey of the First Six Years 1947–1952. Pp. vii+64+8 plates. (London: H.M. Stationery Office, 1953.) 3*s.* [27

British Empire Cancer Campaign. Thirtieth Annual Report covering the year 1952. Edited by Sir Heneage Ogilvie. Pp. xxiv+414. (London: British Empire Cancer Campaign, 1953.) [27

British Cotton Growing Corporation. Progress Reports from Experiment Stations, Seasons 1951–52. Tanganyika Territory, Lake Province. Pp. 14. (London: Empire Cotton Growing Corporation, 1953.) 9*d.* [27

University Grants Committee. University Development: Report on the Years 1947–1952. (Cmd. 8875.) Pp. 93+8 plates. (London: H.M. Stationery Office, 1953.) 3*s.* 6*d.* net. [67

Ministry of Health, Department of Health for Scotland, Ministry of Housing and Local Government. The Fluoridation of Domestic Water Supplies in North America as a means of controlling Dental Caries. Report of the United Kingdom Mission, February–April 1952. Pp. 101+7 plates. (London: H.M. Stationery Office, 1953.) 5*s.* net. [67

First Cape Catalogue of Stars for the Equinox of 1950.0. Catalogue of 5070 Fundamental and Boss Stars, compiled from observations made with the Reversible Transit Circle at The Royal Observatory, Cape of Good Hope, in the years 1936–1944, under the direction of Dr. J. Jackson. Pp. xxvi+102. (London: H.M. Stationery Office, 1953.) 15*s.* net. [67

General Post Office. First Report of the Television Advisory Committee, 1952. Pp. 14. (London: H.M. Stationery Office, 1953.) 1*s.* 6*d.* net. [97

Proceedings of the First International Seaweed Symposium, held in Edinburgh, 14th–17th July, 1952. Pp. viii+131. (Inveresk: Institute of Seaweed Research, 1953.) 10*s.* 6*d.* [97

Other Countries

Bulletin of the American Museum of Natural History. Vol. 101, 1953. Mesozoic Invertebrate Faunas of Peru. Part 1: General Introduction. Part 2: Late Triassic Gastropods from Central Peru. By Otto Haas. Pp. xii+328+18 plates. 6 dollars. Vol. 102, Article 2: Results of the Archbold Expeditions No. 68. Summary of the 1948 Cape York (Australia) Expedition. By L. J. Brass. With notes on the Mammals of Cape York Peninsula by G. H. H. Tate, Curator, Department of Mammals, The American Museum of Natural History. Pp. 135–206+plates 41–47. 1 dollar. (New York: American Museum of Natural History, 1953.) [17

Pharmaceutical Bulletin. Vol. 1, No. 1. March 1953. Pp. 4+99. (Tokyo: Pharmaceutical Society of Japan.) [17

Records of the South Australian Museum. Vol. 11, No. 1. Pp. 90+21 plates. (Adelaide: South Australian Museum, 1953.) [27

Ontario Research Foundation. Report of the Director of Research. Annual Report, 1952. Pp. 28. (Toronto: Ontario Research Foundation, 1953.) [67